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ABSTRACT

The purpose of this research effort is to validate the utility and effectiveness of a unique human performance measurement technique developed under ONR contract (N0001467C0107). Performance data on eight Navy ratings was collected from ships of LANTFLT and PACFLT. This report is the last in a series of technical reports on the statistical analysis of that data. A statistical analysis is provided on performance related data for electronic maintenance personnel sampled from 21 ships. Four different performance estimators, as functions of critical incidents, were evaluated. A detailed explanation of the distributional properties of the performance estimators is presented, and an explanation of the factors that lead to the adoption of a curvilinear regression analysis for analysis of the data is discussed. The results of the statistical analysis indicated that a certain combination of the performance data possessed moderate validity for appraising the absolute level of technician on-the-job performance on the EM, ET, FT, and IC ratings. Application of the technique to technicians in the RM, ST, and TM ratings was tenuous, but still appropriate, while none of the performance estimators seemed to be applicable to technicians in the RD rating. For this reason, it would seem that the appropriateness of application of this technique to other ratings warrants investigation, perhaps by the approach employed in this report. In any event it has been observed that the technique possesses sufficient merit to be recommended for more widespread use within the U. S. Navy. (Author)

NAVAL PERSONNEL RESEARCH AND DEVELOPMENT LABORATORY

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AN ANALYSIS OF A FLEET POST-TRAINING PERFORMANCE MEASUREMENT TECHNIQUE

Bernard A. Rafacz
Paul P. Foley

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AN ANALYSIS OF A FLEET POST-TRAINING PERFORMANCE MEASUREMENT TECHNIQUE

Bernard A. Rafacz
Paul P. Foley

Principal Investigator: Paul P. Foley

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NAVAL PERSONNEL RESEARCH AND DEVELOPMENT LABORATORY
WASHINGTON, D.C. 20374

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FOREWORD

This research effort is being performed with the support of the Personnel and Training Research Programs Office, Office of Naval Research, under Project Order No. 2-0046, Work Unit Number NR 150-336 entitled PERSONNEL TECHNOLOGY: Relating Individual Performance Effectiveness to Unit and Ship Effectiveness. This is a final report on the analysis of the performance data collected in the course of the project.

Appreciation is expressed for the cooperation and assistance provided by Commander, Cruiser-Destroyer Force, Atlantic Fleet, Commander, Cruiser-Destroyer Force, Pacific Fleet, and Commander, Cruiser-Destroyer Flotilla NINE for providing the ships and men that took part in the data collection effort of this project.

The authors are indebted to Mr. William A. Sands of the Naval Personnel Research and Development Laboratory for his critical reading of the manuscript and invaluable suggestions on presenting the results of the data analysis.

The assistance of Dr. Arthur I. Siegel of Applied Psychological Services, Inc., Wayne, Pennsylvania, is also appreciated for providing some of the computer programs which were employed in analyzing the performance related data.

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1. Enclosure (1) is an evaluation of four different performance estimators relative to a criterion measure of absolute technician performance. The technicians were involved in fleet electronic maintenance activities in one of the ratings - EM, ET, FT, IC, RD, RM, ST, and TM.

2. The report is forwarded for information. Comments and recommendations are invited.

A. L. Blanks

A. L. BLANKS

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SUMMARY AND CONCLUSIONS

Problem

The advent of a more streamlined Navy operating under reduced manning levels and heightened operational requirements imposes the need for accurate human-performance evaluation of ship personnel systems. On the personnel systems level, electronic technician reliability measurement is a necessary and integral part in the evaluation of particular combat systems of which technicians are components. The objective is then to develop and evaluate human-performance reliability estimates so as to be able to effectively alter the personnel system in order to maximize the overall performance of the system. The purpose of this project is to validate the utility and effectiveness of a unique human performance measurement procedure developed under a prior Office of Naval Research project and designed to improve upon existing performance measuring techniques in a systems environment.

Background and Requirements

Human reliability performance estimation can be accomplished by considering the individuals being evaluated as components of a personnel system. This consideration allows the use of much of the theory already applied to equipment reliability estimation to be modified to human-performance estimation. After this theory is applied to evaluate the performance of human components in a personnel system, appropriate combinations of the individual performance estimators will provide a performance or reliability estimate of the personnel system itself.

In order to improve upon existing performance estimators of the human component in a personnel system, Dr. Arthur I. Siegel and his associates of Applied Psychological Services, Inc., Wayne, Pennsylvania, developed fleet post-training performance criteria for electronic maintenance personnel with the support of the Office of Naval Research. The cumulation of these efforts resulted in the development of unique human performance measurement techniques, closely allied with equipment reliability estimation techniques. Siegel also developed procedures for combining the technician performance estimates in appropriate ways in order to estimate team, ship or squadron performance.

An outgrowth of the prior research effort was the suggestion that the techniques be introduced on a limited basis to determine how they may be modified or elaborated upon. The Naval Personnel Research and Development Laboratory has been validating the utility and effectiveness of these techniques. The main technical objectives of this validation effort are to determine the validity of the performance measurement techniques, identify modifications required to maximize their possibility for implementation and to comment on the statistical properties of those techniques as related to their effectiveness in an operational context.

Approach

In order to realize an efficient and timely data collection effort, optical scanning instruments were utilized similar to those employed by Applied Psychological Services in prior research efforts.

The main data collection instruments were:

1. Job Performance Questionnaire (JPQ) ANSWER SHEET - this form records supervisory estimates of the total number of a technician's uncommonly effective (ΣUE) and uncommonly ineffective performance (ΣUI) that the supervisor has observed during a specified time period.

2. Technical Proficiency Checkout Form (TPCF) - this form records the level of technical complexity at which a man is able to perform without direct supervision.

3. Personnel Identification Information Form (PIIF) - this form records demographic data on the technician being evaluated.

On each of the above instruments an individual in one of the electronic maintenance ratings EM, ET, FT, IC, RD, RM, ST, and TM was evaluated by his supervisor. On the basis of the total number of uncommonly effective (ΣUE) and the total number of uncommonly ineffective (ΣUI) incidents of performance recorded on the Job Performance Questionnaire (JPQ), three different performance estimators were developed previously by Applied Psychological Services. These estimators are functions of the total number of uncommonly effective (ΣUE) and the total number of uncommonly ineffective (ΣUI) incidents of performance observed by the supervisor on each of eight job dimensions characteristic of electronic maintenance activities. The three estimators of human reliability are:

1. Series Reliability Estimate (SRE)

2. Series-Parallel Reliability Estimate (PRE)

3. Geometric Mean Reliability Estimate (GRE)

In addition, a fourth measure of technician on-the-job performance developed in the course of this research effort was:

4. Weighted-Average Reliability Estimate (WRE).

By adopting the Technical Proficiency Checkout Form (TPCF) as a criterion measure of technician on-the-job performance, the degree of association between each of the four performance estimators and criterion measure was developed for various locations and each rating. Furthermore, a curvilinear regression analysis was applied to determine the best linear relationship between those variables.

While the purpose of this project was not to evaluate the criterion measure (TPCF), conditional and joint frequencies of the job tasks by rating revealed the modifications needed on the TPCF to make it more current. Furthermore, from the conditional and joint frequencies it was possible to develop a competency level for each rating and permit an in-depth analysis of the job task structure for those ratings.

Comparisons between ships and ratings were made by employing the WRE since it was identified as a more promising performance estimator. Initially a two-way Analysis of Variance was employed on the sample data. However, because of the significant interaction that was found to exist between ships and ratings, comparisons between ships (ratings) were made for a fixed rating (ship).

Finally, product-moment correlation coefficients were developed between various performance variables and several demographic variables. In particular, Basic Test Battery scores (GCT, ARI, MECH, and CLER scores), usually employed to predict actual school success, were investigated in order to determine the degree of association between those scores and the measures of on-the-job performance developed in this research effort.

Findings

In order to determine the appropriateness of standard statistical techniques or tests employed for various purposes in this research effort, initial findings were concerned with the results of an analysis of the distributional properties of the predictor and criterion variables. From an application of appropriate goodness-of-fit tests for normality to the sample data, only the predictor variable WRE could be termed normally distributed. This result was also generally true when individual ratings were similarly studied. These characteristics of the sample data necessitated the use of a curvilinear regression analysis. An emphasis on only the least-squares analysis resulting from an application of that technique was employed in order to determine the relative merits of each of the predictor variables.

A comparison of the multiple correlation coefficients resulting from the curvilinear regression analysis applied across all ratings revealed that a straight-line was the best fit to the sample data. The product-moment correlations between the predictor variables (SRE, PRE, GRE, and WRE) and the selected criterion variable suggested moderate promise on the part of the WRE for appraising the on-the-job performance of individuals involved in electronics maintenance activities. However, the relatively low multiple correlation coefficients suggested a significant degree of unexplained criterion variance. As such the analysis was applied by rating. Relevant findings by rating revealed that in almost every rating the WRE demonstrated more promise for appraising on-the-job technician performance than the other estimators. The WRE was considered a more promising estimator in the sense that the sample product-moment correlation coefficients were generally of a larger magnitude and, by some fit to the data, the WRE seemed to account for more criterion variance. For example, the WRE indicated product-moment correlations of .492, .445, .430, and .434 for the EM, ET, FT, and IC ratings, respectively, while the next more promising estimator (GRE) demonstrated product-moment correlations of .301, .508, .374, and .387 for the EM, ET, FT, and IC ratings, respectively. It is to be noted that while the WRE may not necessarily be a statistically significantly different estimator in terms of producing higher correlations with the criterion variable and explaining more criterion variance, the sample data results did tend to demonstrate that the WRE was the more promising estimator in that consistently the sample results did produce higher product-moment and multiple correlation coefficients for the WRE. Altogether the WRE demonstrated very promising results on the EM, ET, FT, and IC ratings and fair results on the RM, ST, and TM ratings. None of the performance estimators were at all promising in the RD rating.

Relevant findings from an analysis of the Technical Proficiency Checkout Form revealed that it was a very instructive instrument for determining technician proficiency in one job task in relation to another. Only one job task - the calibrating of the equipment used by the technicians - seemed to be out of place in the hierarchial order of the job tasks represented by this instrument.

Findings of the multiple comparison of ships and ratings included the result that significant interaction exists between ship-rating combinations. This resulted in the development of multiple comparisons of ships (ratings) for a fixed rating (ship). From this analysis it was found that no pairwise significant difference exists between ships. On some ships a pairwise significant difference exists between some ratings, but no pattern emerged across ships as to which rating(s) demonstrated a higher or lower mean performance level.

The product-moment correlation coefficients developed between the demographic variables and the performance variables were of the same magnitude as those which are usually found to exist between predictor variables and measures of on-the-job performance. Promising results were found in this research effort on the relationship of demographic variables to on-the-job performance.

Conclusions

Employing the TPCF as a criterion measure of technician on-the-job performance it may be stated that the following list represents an accurate portrayal of the performance measurement technique that was researched:

1. The distribution of the predictor variables SRE, PRE, and GRE are generally skewed in one direction or another, while the criterion variable derived from the TPCF is negatively skewed. The WRE is normally distributed. These conclusions are for each rating and across ratings.

2. The WRE is a more promising type of performance estimator. It has greatest utility when applied to technicians in the EM, ET, FT, and IC rating and fair promise for application in the RM, ST, and TM ratings.

3. None of the performance estimators is appropriate for use upon technicians in the RD rating.

4. The Technical Proficiency Checkout Form (TPCF) demonstrated significant promise for appraising the job task structure and proficiency of electronics maintenance personnel without restriction to a particular rating.

5. In all ratings a more current factor analytic task analysis would be desirable before implementation of the technique. This would involve a revision of the job activity factors on the JPQ ANSWER SHEET and job task descriptions on the TPCF by rating.

6. It is recommended that a validation of the performance variables (SRE, PRE, GRE and WRE) be completed before the technique is applied to other than those ratings researched in this report.

In conclusion it is to be noted that the performance measurement technique that was researched is of significant merit to be considered for practical application in the U.S. Navy (particularly in the EM, ET, FT, and IC ratings). At the present stage in the art of developing performance measurement techniques, the technique that was researched is probably the best performance measurement procedure presently available for application within the U. S. Navy.

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INTRODUCTION

Current and expanded commitments of a modern sophisticated Navy will require greater operational effectiveness of fleet personnel systems. The Navy will have to operate fleet personnel systems at optimal effectiveness levels and maintain fleet readiness. Together with these requirements, the advent of an all-volunteer force and smaller ship systems with reduced manning levels make the problem of optimizing, and evaluating, personnel system effectiveness a complex and critical problem.

While performance assessment serves a multitude of purposes, it has been seen as an especially valuable tool when applied to the areas of optimizing personnel system performance, providing feedback on naval school effectiveness, the interpretation of man-machine interaction, and as a factor in the optimal assignment of men to jobs. It is in these applications that personnel systems performance measurement will be able to address some of the more critical present-day Navy problems. For example, many ship systems are operating with increasingly sophisticated and complex equipment. However, is it necessarily true that technicians of comparable sophistication in training and mental ability need to be employed to operate, maintain, and repair that equipment in order that the ship complete its mission? While this report does not address that specific question, future research employing individual, and system, performance measurement may reveal that the Navy could effectively utilize personnel in those positions who may now be rejected for some reason related to their projected on-the-job performance in those positions. As such there is a definite need for valid and reliable individual system performance assessment.

In order to achieve a performance appraisal of personnel systems, recent research has been directed towards viewing personnel system performance estimation as analogous to equipment reliability estimation. This particular approach views individuals (in the system) as "components" in the personnel system. This viewpoint, and an application of the techniques already employed in equipment performance estimation, reduces personnel system performance estimation to an evaluation of the performance of the individuals in the system. Once the individual performance estimates have been made, meaningful combinations of these estimates can provide estimates of personnel system performance. As such the initial problem reduces to that of finding accurate and valid measurements of individual performance.

Much recent research in the area of individual performance measurement has been directed towards examining individual performance as a function of the extremes of behavior (critical incidents) of an individual's performance. These functions of behavior can provide estimates of individual performance. By appropriate combinations of the individual performance estimates, estimates of personnel system performance can be developed. This report will address the validity, application, and implications of a particular procedure that employs the critical incidents technique to estimate the performance of electronics maintenance personnel.

BACKGROUND

The purpose of this section is to give the reader a logical development of the performance measurement techniques employed by Applied Psychological Services and others. Fundamentally these researchers employed a critical incidents technique in deriving estimates of human performance.

Generally the main approach is to estimate the performance of a particular personnel system as a function of the performance of individuals that are a part of the system. This necessarily reduces personnel system performance estimation to a discussion of estimators of individual performance where individuals are the components of the system. Combining the individual estimates will provide estimates of personnel system performance.

Personnel Performance Estimation

Let UE (UI) represent an uncommonly effective (uncommonly ineffective) incident of performance observed by a rater in a certain time period on some individual under observation. Furthermore, let ΣUE (ΣUI) represent the total number of uncommonly effective (uncommonly ineffective) incidents of performance observed. Using these functions of critical incidents, Whitlock [21][1] demonstrated that there is a definite straight line or curvilinear relationship between ΣUE (or the ratio ΣUE/ΣUI) and corresponding performance evaluations. Prior results such as this provided significant evidence that the application of a critical incidents technique to performance evaluation is a valid and useful approach.

Following upon the results of Whitlock, for example, Applied Psychological Services further developed and applied the above mentioned techniques to the post-training performance evaluation of individuals in various avionic or electronic ratings in the U. S. Navy. In particular Siegel and Pfeiffer [18], utilizing estimates of uncommonly effective and uncommonly ineffective performances, showed that these estimates possess merit as useful indicators of overall personnel proficiency. The researchers employed magnitude estimates of the number of uncommonly effective and uncommonly ineffective performances relative to a short prior period for avionic personnel. They derived a performance index from the ratio of the sum of uncommonly effective performance (ΣUE) to the sum of uncommonly effective plus the sum of uncommonly ineffective performance (ΣUI), namely (ΣUE/[ΣUE + ΣUI]). Siegel and Pfeiffer [18] concluded that: (1) magnitude estimates of uncommonly effective and ineffective performance yielded useful data which could form the basis for a personnel subsystem reliability index; (2) the ratio of the sum of uncommonly effective to the sum of uncommonly effective plus the sum of uncommonly ineffective performance yields an index which discriminates in the anticipated direction; and, (3) the obtained avionic personnel subsystem index could be utilized for post-training performance appraisal, personnel placement, and squadron evaluation purposes.

Job Performance Questionnaire

Eight job activity factors descriptive of naval avionic electronic maintenance jobs were isolated by Siegel and Schultz [19] and are shown in Appendix A, page A-7, along with their definitions. These factors formed the basis of the Job Performance Questionnaire (JPQ), an instrument for recording the frequency of critical incidents for each of the job activity factors. Siegel and Federman [16] demonstrated the utility and practicality of a Job Performance Questionnaire (Appendix A, page A-3) for technicians in the eight electronic maintenance ratings EM (electrician's mate), ET (electronics technician), FT (fire control technician), IC (interior communications electrician), RD (radarman), RM (radioman), ST (sonar technician), and TM (torpedoman's mate). From an evaluation of 499 technician in those ratings, the researchers found that the JPQ yields an estimate of the total number of uncommonly effective and uncommonly ineffective incidents of behavior on the eight identified job activity factors.

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[1]All numbers enclosed in brackets refer to corresponding numbers of documents and publications listed under REFERENCES.

Specifically, for each job activity the reliability ratio ($\Sigma UE/[\Sigma UE + \Sigma UI]$) yields an estimate of the probability of effective performance for the individual technician on the particular job activity considered. Then the reliability ratios are compounded to provide estimates of individual effectiveness or reliability of on-the-job performance across the job activities. It was reported by Siegel and Federman [16] that estimates of uncommonly effective and of uncommonly ineffective behavior along all eight dimensions of job activities could be combined into a meaningful measure of technician effectiveness. Moreover, they indicated that the individual technician effectiveness values can be further treated to form effectiveness values for ratings, ships, and squadrons.

Estimation of Technician Reliability

Employing the reliability ratio concept ($\Sigma UE/[\Sigma UE + \Sigma UI]$), Siegel and Federman [16] have developed the following three reliability estimates:

1) Series Reliability Estimate (SRE)
The series reliability measure of total effectiveness for an individual is derived by multiplying individual job activity reliability ratios to yield a total reliability score, i.e.,

$$R_s = r_1 \times r_2 \times \ldots \times r_8$$

where R_s = series reliability[2], and

r_i = ($\Sigma UE/[\Sigma UE + \Sigma UI]$) is the reliability ratio for the i^{th} job activity.

It is to be noted that use of the series reliability estimate requires the assumption that performance reliability on each job activity is independent of performance reliability on other job activities.

2) Series Parallel Reliability Estimate (PRE)
Siegel and Federman [16] reported that "... the series and series-parallel reliabilities provide measures of personnel proficiency relative to performance on the entire job (i.e., all eight job activities).", (p. 46). The series-parallel estimate of individual proficiency is defined as:

$$R_p = R_s \times (2 - r_1) \times \ldots \times (2 - r_8)$$

where R_s and r_i ($i = 1, \ldots, 8$) are defined in 1) above.

---

[2] It is helpful to note that the series reliability estimate possesses the following properties:

a) for each of the $i = 1, \ldots, 8$ job activities

$0 \leq r_i \leq 1$, and, therefore,

b) $0 \leq R_s \leq 1$

c) $R_s \leq$ smallest r_i.

This particular estimate tends to provide a more optimistic estimate of individual performance. However, the content validity and derivation of this estimate deserves further development.

3) Geometric Mean Reliability Estimate (GRE)
Let r_1^*, r_2^*, r_3^*, and r_4^* be the four highest job activity reliability ratios of the eight reliability ratios for a technician being evaluated. The geometric mean reliability for the technician is defined as:

$$R_g = \sqrt[4]{r_1^* \times r_2^* \times r_3^* \times r_4^*}.$$

This particular estimate is an estimate of individual performance that stresses the strong points of an individual's performance. However, it also tends to ignore his weak points and, therefore, should be used with caution.

In addition to the three performance estimators (SRE, PRE, and GRE) previously introduced, this report will also discuss an estimate that weights the importance of each job activity in determining a technician's overall performance.

4) Weighted Average Reliability Estimate (WRE)
To develop this estimate let:

NJ = number of job activities on which the technician actually worked;

i = index for the sum over the job activities on which the technician actually worked;

r_i = the reliability ratio for the i^{th} job activity;

w_i = weight denoting the importance of the i^{th} job activity in estimating the technician's overall performance.[3]

The Weighted-Average Reliability Estimate (WRE) of technician effectiveness is then defined as:

$$R_W = \sum_{i=1}^{NJ} r_i \times w_i/NJ$$

Validation of Performance Estimators

In addition to performance data collected on the JPQ, performance data were collected by Siegel and Federman [16] by means of an evaluative instrument called the Technical Proficiency Checkout Form (TPCF) (Appendix A, page A-5). The TPCF consists of eight job tasks listed in hierarchial order from easiest to most difficult. The eight tasks meet the Guttman requirements for scalability (see for example, Guttman [11]). Siegel, Schultz, and Lanterman [20], 1964, employed the scale underlying the eight tasks to determine the cutting points for placing avionic petty officers, third class and strikers in one of three levels of technical proficiency. The procedure for placing a technician in one of three levels of technical proficiency is accomplished by means of a Technical Proficiency (TP) score developed from the TPCF.

[3]The procedure for deriving the weights is given in Appendix K.

Technical Proficiency (TP) Score

Define the function F_i ($i = 1, \ldots, 8$) as:

$$F_i = \begin{cases} 1 & \text{if the technician is CHECKED OUT on the } i^{th} \text{ task of the TPCF} \\ 0 & \text{if the technician is NOT CHECKED OUT on the } i^{th} \text{ task of the TPCF.} \end{cases}$$

The TECHNICAL PROFICIENCY (TP) score for a technician is then defined as:

$$\text{TP score} = \sum_{i=1}^{8} F_i .$$

Technical Proficiency Checkout (TPC) Level

Three TECHNICAL PROFICIENCY CHECKOUT (TPC) levels are:

Level 1: above desirable

Level 2: below desirable but at least minimally acceptable

Level 3: below minimally acceptable.

Siegel, Schultz, and Laterman [20] based this trichotomous division of the TPCF on supervisor's judgments of the performance level required for achieving the objectives given in Appendix A, page A-8.

The procedure for determining the TPC level was reported on in the previously mentioned report and is given by:

a) add 0.5 to TP score for an individual. Let TP* be the resultant score.

b) if $TP^* < 3.92$, the TPC level = 3

c) if $3.92 \leq TP^* \leq 5.63$, the TPC level = 2

d) if $TP^* > 5.63$, then TPC level = 1.

Siegel and Fischl [17] correlated technicians TPC levels with the technicians total scores on a performance test. Employing a triserial correlation coefficient (see, for example, Jaspen [13]) as an estimate of the product-moment correlation, they found a triserial correlation of .40. When corrected for the lack of perfect reliability in the performance test criterion, the correlation became .74. On the basis of their investigation of the then concurrent validity of the TPCF, they concluded that the Technical Proficiency Checkout Form, "... previously shown to be reliable and practical, may now be considered to possess a substantial degree of validity for appraising the absolute proficiency level of avionics technicians in the fleet.", (p. 46). Finally, Siegel and Federman [16] recorded a triserial correlation of .38 between the TPC level of the technicians evaluated and their Series Reliability Estimate (SRE), concluding "... there is some basis to believe that the JPQ results correlate with on-the-job performance.", (p. 62).

Main Results of Prior Studies

Important conclusions of prior reports relative to the merits of the Series Reliability Estimate (SRE), Series-Parallel Reliability Estimate (PRE), Geometric Mean Reliability Estimate (GRE), and the Technical Proficiency Checkout Form (TPCF) are as follows:

1. Reliability ratios of the form $\Sigma UE/(\Sigma UE + \Sigma UI)$ indicate the probability of effective performance on a particular job activity for the technician being evaluated.

2. The JPQ is an instrument for providing magnitude estimates of ΣUE and ΣUI for each man being evaluated by his immediate supervisor.

3. The TPCF possesses a substantial degree of promise for appraising the absolute level of avionic technician proficiency.

4. There is some basis (triserial correlation of .38 with TPC level) to believe that the SRE is a reasonably good estimator of on-the-job performance.

PURPOSE

The purpose of this research effort is to report on the data collection effort and data reduction methods and analyses that have been performed for the Office of Naval Research (ONR) under the project entitled Personnel Technology: Relating Individual Performance Effectiveness to Unit and Ship Effectiveness (Project Order Number: PO 2-0046 NR 150-336). The goal of this research project is to provide an empirical basis for assessing the utility to the Navy of a performance measurement technique developed under a prior ONR contract. Under that contract Dr. Arthur I. Siegel, Philip J. Federman, and their associates of Applied Psychological Services, Inc., Wayne, Pa., developed fleet post-training performance evaluative measures which have potential value for eventual widespread implementation within the U. S. Navy. The results of their study were contained within the report - Development of Performance Evaluative Measures: Investigation into and Application of a Fleet Post-Training Performance Evaluative System [16]. An outgrowth of that effort was the suggestion that the technique be employed on a limited basis by a Navy laboratory to identify areas of modification upon operational testing. In response to that recommendation the Naval Personnel Research and Development Laboratory submitted a proposal to ONR to accomplish that task. Essentially the research effort undertaken by NAVPERSRANDLAB was accomplished by replicating the efforts of Siegel and Federman [16].

A second major objective of this research effort was to further develop the performance measurement techniques of Siegel and Federman [16]. Furthermore, similarly related performance measurement techniques were researched with a view towards possible implementation of those techniques within the U. S. Navy.

DATA COLLECTION

The procedures employed in data collection for this project closely paralleled those employed by Siegel and Federman [16], with some modifications in the research instruments. This procedure was adopted so that a similar statistical analysis on the same type of population would permit some comparisons to be made between the results of this research effort and the results obtained by Siegel and Federman [16].

Every effort had been made to minimize interfering with normal shipboard duties. For this reason the data collection procedure centered upon the efforts of ship liaison officers conducting the data collection aboard each ship. Appendix B contains a discussion on the procedures for the data collection reflecting various aspects of the effort that resulted in the orderly and successful completion of the task.[4]

Data Collection Instruments

An example of the performance evaluation forms that were completed by each supervisor for each technician evaluated are given in Appendix A. The instruments are optical scanning forms, thus, making them machine-readable and more capable of being placed in an operational mode. In particular the forms were:

1) Job Performance Questionnaire (JPQ) ANSWER SHEET
This form serves the same purpose as the JPQ discussed earlier, i.e., to record estimates of the total number of uncommonly effective (ΣUE) and uncommonly ineffective (ΣUI) performances the supervisor has observed on each of the eight job activities for each man he is evaluating.

2) Technical Proficiency Checkout Form (TPCF)
This form is essentially identical to the TPCF used by Siegel and Federman [16].

3) Personnel Identification Information Form (PIIF)
This form was concerned with the background data of the man being evaluated. It was completed in part by his supervisor with the Administrative Officer providing the remaining information.

Analyses Based on the Data Collection Effort

Employing the data collection instruments discussed in the previous section, performance data were collected with the assistance of men and ships of Commander; Cruiser-Destroyer Flotilla NINE (located at San Diego, California) and men and ships of Commander; Cruiser-Destroyer Force Atlantic Fleet (located at Newport, Rhode Island, and Boston, Massachusetts).[5] The participating ships and type are shown in Table 1 along with the number of men evaluated by rating and ship for each location.

Analyses Based on the Job Performance Questionnaire

A descriptive analysis of each of the performance estimators (SRE, PRE, GRE, and WRE) derived from the Job Performance Questionnaire (JPQ) is presented in Figures 1, 2, 3, and 4 and in the form of histograms. Each of these histograms was developed on 949 technicians and based on the performance estimators which are continuous over the range of 0.0 to 1.0. Class intervals are numbered from 1 through 21 where a given class interval is of length .05. Class intervals corresponding to each of the numbered intervals are provided in Table 2.

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[4] For the interested reader Appendices C and D contain the instructions for the ship liaison officer and the technician supervisor, respectively.

[5] Henceforth in this report Location No. 1 will refer to ships at San Diego, Calif., and Location No. 2 will refer to ships at either Newport, R.I., or Boston, Mass.

TABLE 1

NUMBER OF MEN IN EACH RATING AND SHIP

CRUDESFLOT NINE (Location No. 1)

Ship	Type	EM	ET	FT	IC	RD	RM	ST	TM	TOTAL
USS AGERHOLM	DD-826	6	7	7	4	5	5	5	3	42
USS BROOKE	DEG-1	6	8	16	3	10	8	9	1	61
USS GRAY	DE-1054	5	10	5	4	9	7	9	1	50
USS HORNE	DLG-30	4	12	11	6	5	5	8	2	53
USS HULL	DD-945	3	9	8	3	9	9	8	1	50
USS JOUETT	DLG-29	5	10	12	5	7	6	9	2	57
USS PRAIRIE	AD-15	6	29	12	6	0	10	0	13	76
USS RUPERTUS	DD-851	5	11	3	2	9	9	10	1	50
USS SHELTON	DD-790	4	5	5	1	5	5	5	0	30
USS SOUTHERLAND	DD-743	5	8	9	5	11	11	9	2	60
USS HENRY W. TUCKER	DD-875	5	9	0	3	13	11	11	2	54
TOTAL		54	118	88	42	83	86	83	28	582

CRUDESLANT (Location No. 2)

Ship	Type	EM	ET	FT	IC	RD	RM	ST	TM	TOTAL
USS BASILONE	DD-824	4	4	5	0	0	5	5	0	23
USS DEALEY	DE-1006	3	6	5	2	3	4	6	1	30
USS DEWEY	DLG-14	6	6	6	4	6	5	6	2	41
USS FISKE (Boston)	DD-842	5	4	5	0	5	5	6	0	30
USS J. A. FURER	DEG-6	4	5	14	4	5	8	5	2	47
USS GARCIA (Boston)	DE-1040	4	6	6	2	6	8	10	2	44
USS GLOVER (Boston)	AGDE-1	4	7	3	0	6	6	12	1	39
USS HUGH PURVIS	DD-709	6	7	10	0	15	0	9	2	49
USS TALBOT	DEG-4	5	5	9	2	5	5	5	0	36
USS JOHN WILLIS	DE-1027	2	5	3	2	5	5	5	1	28
TOTAL		43	55	66	16	56	51	69	11	367
TOTAL (BOTH LOCATIONS)		97	173	154	58	139	137	152	39	949

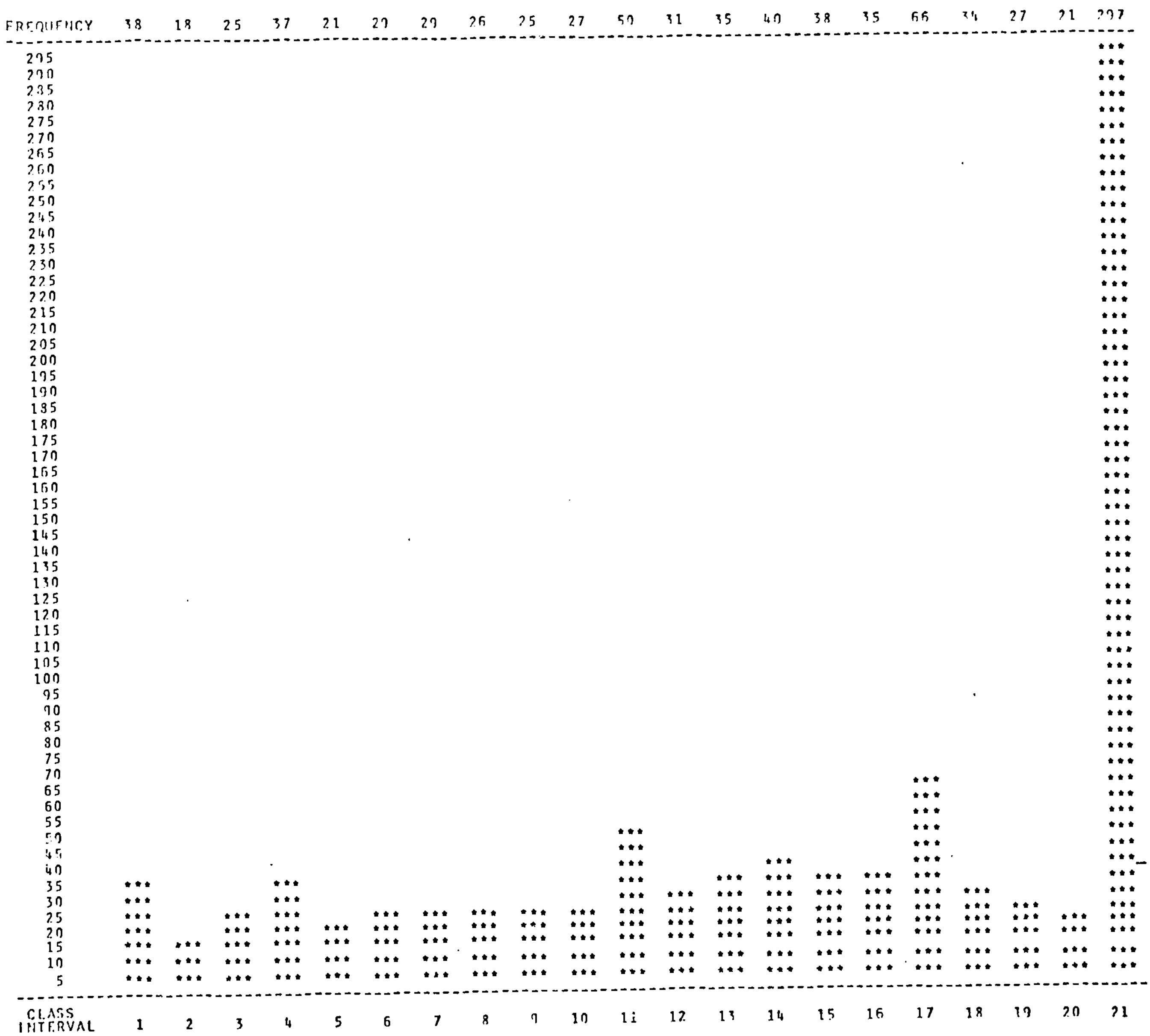

Fig. 1.--Histogram of Series Reliability Estimates (SRE)

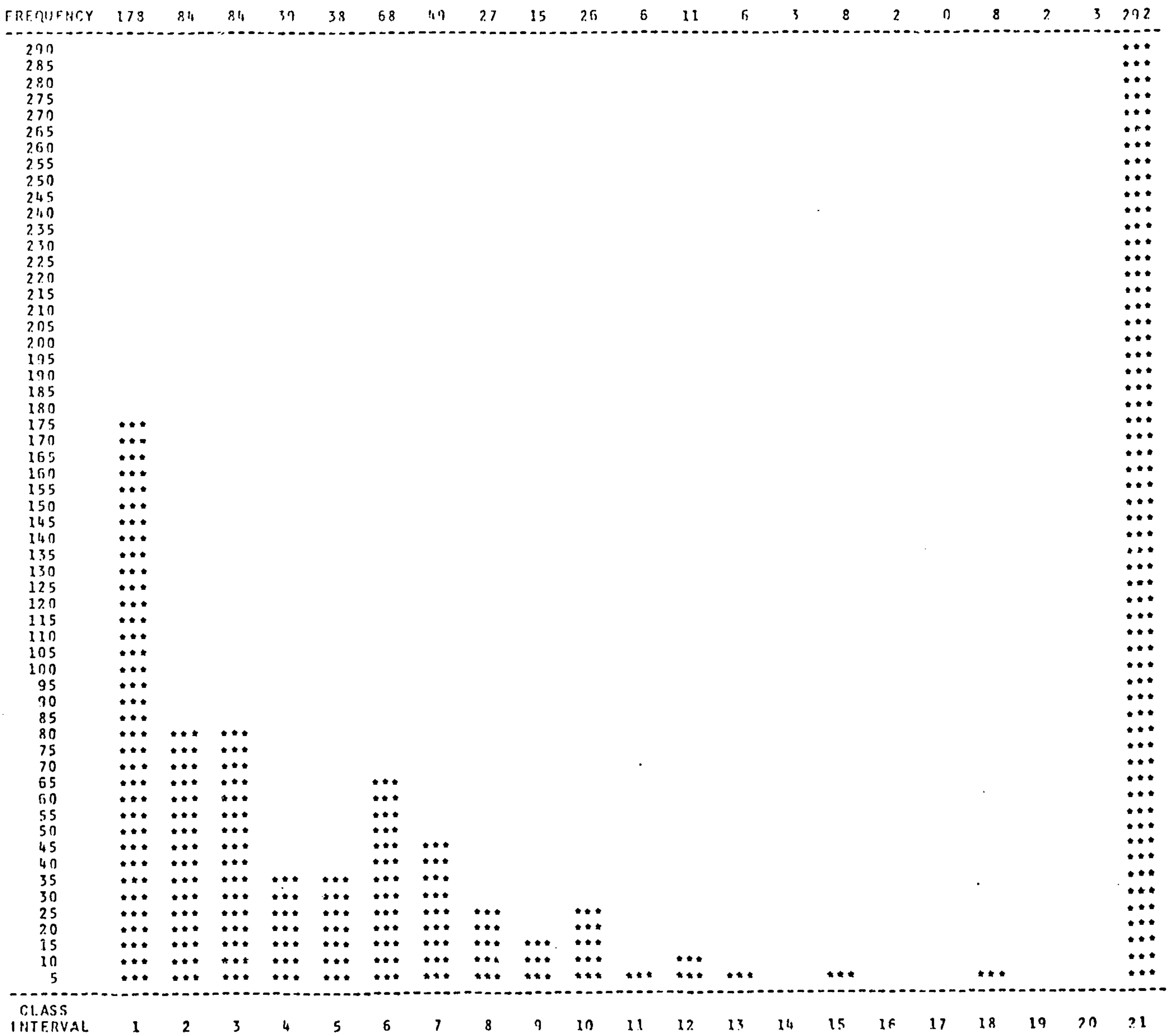

Fig. 2.--Histogram of Series-Parallel Reliability Estimates (PRE)

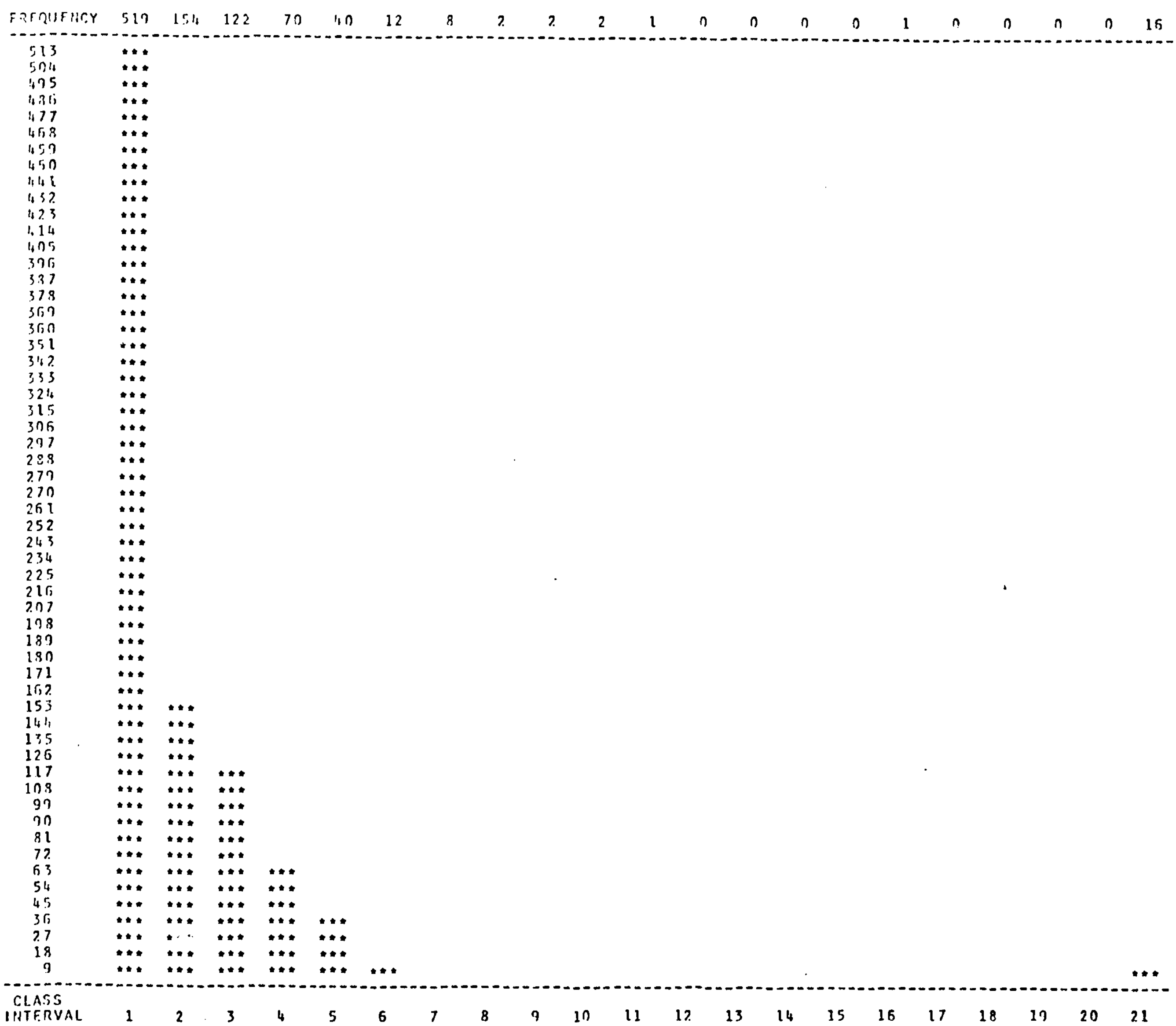

Fig. 3.--Histogram of Geometric Mean Reliability Estimates (GRE)

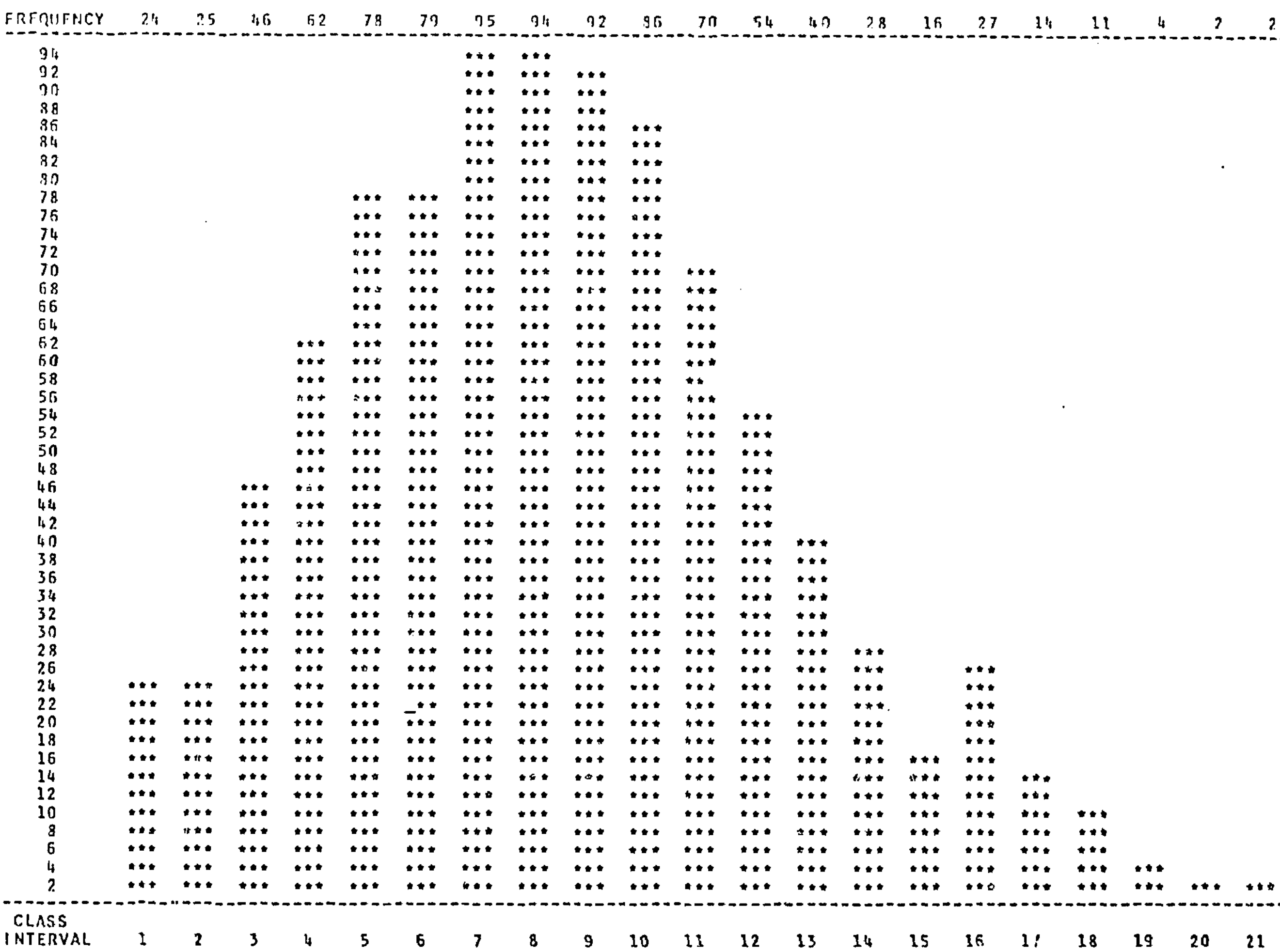

Fig. 4.--Histogram of Weighted-Average Reliability Estimates (WRE)

TABLE 2

CLASS INTERVALS FOR HISTOGRAMS

Class Interval Number	Lower Boundary	Upper Boundary
1	0.96	1.00
2	0.91	0.96
3	0.86	0.91
4	0.81	0.86
5	0.76	0.81
6	0.71	0.76
7	0.66	0.71
8	0.61	0.66
9	0.56	0.61
10	0.51	0.56
11	0.46	0.51
12	0.41	0.46
13	0.36	0.41
14	0.31	0.36
15	0.26	0.31
16	0.21	0.26
17	0.16	0.21
18	0.11	0.16
19	0.06	0.11
20	0.01	0.06
21	0.00	0.01

Further analysis of results on the JPQ ANSWER SHEET indicated a high frequency of nonresponse in some job activities and ratings. The type of nonresponse that resulted was for the case in which the man being evaluated did not work at the particular job activity under consideration. Furthermore, there was also a significantly high proportion of men who, while they worked at the job activity being considered, received $\Sigma UE = 0$ and $\Sigma UI = 0$ from their supervisors. These observations required the consideration of two important areas relative to the JPQ.

Problems in Calculating Performance Estimates. As discussed in the Background section of this report, reliability ratios of the form ($\Sigma UE/[\Sigma UE + \Sigma UI]$) were derived for each man on each of eight job activities and these ratios were combined to form the SRE, PRE, and GRE. However, the following two cases require the adoption of some convention in order to calculate the reliability ratios:

1) the technician did not work at that job activity, or

2) the technician received $\Sigma UE = 0$ and $\Sigma UI = 0$ by the supervisor, implying that the reliability ratio $\frac{0}{0 + 0}$ is undefined.

By observing the frequency with which such cases occur across all 21 ships participating in the project, it is possible to determine the extent to which any convention for estimating performance in those cases would effect individual SRE, PRE, and GRE values. A complete discussion of this effect is given in Appendix E. Summarizing, the above two cases can have a dramatic affect upon the individual performance estimates and these estimates will be greatly influenced by the convention that is adopted.

A Convention for Estimating Performance in Certain Job Activities. Siegel and Federman [16] employed "... the average value for his rating on his ship ...", (p. 28), on those job activities which the technician did not work at or received $\Sigma UE = 0$ and $\Sigma UI = 0$ by his supervisor. Unfortunately the results of the data collection effort at Location No. 1 (Destroyer Flotilla NINE) and at Location No. 2 (Cruiser-Destroyer Force Atlantic Fleet) indicated that this technique was not feasible.[6]

In order to overcome this problem, the convention adopted in this report was to employ a composite reliability value across all ships at a location for each job activity and rating. Appendix F discusses the procedure for deriving the composite reliability values, as employed in this report.

Analyses Based on the Technical Proficiency Checkout Form

Table 3 represents the numbers of men at each of the three TPC levels by rating and ship and across each rating and ship at Location No. 1. Table 4 reflects the same information for Location No. 2. It will be remembered that level 1 reflects an "above desirable" proficiency level while level 3 reflects a "below minimally acceptable" proficiency level.

In addition to the TPC levels, TP scores were developed. A histogram of the resulting TP scores for the 949 technicians evaluated is presented in Figure 5. Almost identical histograms of TP scores were obtained for data collected at the two locations. Hence, only one histogram is presented.

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[6] On every ship sampled at those locations there were ratings for which in some job activities those two cases occurred for all men in that rating. Appendix F provides a detailed account of this problem for the interested reader.

TABLE 3

NUMBER OF MEN AT EACH TECHNICAL PROFICIENCY CHECKOUT (TPC) LEVEL

Location No. 1

RATING	TPC LEVEL	SHIP 1	2	3	4	5	6	7	8	9	10	11	EACH RATING
EM	1	4	5	4	2	1	4	5	3	2	5	3	38
	2	1	1	0	1	1	1	1	2	2	0	2	12
	3	1	0	1	1	1	0	0	0	0	0	0	4
ET	1	4	6	7	9	7	8	17	8	5	8	7	86
	2	2	2	3	1	2	1	9	2	0	0	1	23
	3	1	0	0	2	0	1	3	1	0	0	1	9
FT	1	5	10	3	10	8	8	6	2	2	5	0	59
	2	2	5	0	0	0	3	3	0	3	0	0	16
	3	0	1	2	1	0	1	3	1	0	4	0	13
IC	1	2	2	2	5	1	3	4	2	1	2	2	26
	2	1	0	1	1	1	2	1	0	0	3	0	10
	3	1	1	1	0	1	0	1	0	0	0	1	6
RD	1	0	0	0	0	0	0	0	0	0	1	0	1
	2	1	1	1	0	1	0	0	8	0	3	0	15
	3	4	9	8	5	8	7	0	1	5	7	13	67
RM	1	1	3	7	0	0	4	4	1	5	0	0	25
	2	1	4	0	0	8	2	3	5	0	2	8	33
	3	3	1	0	5	1	0	3	3	0	9	3	28
ST	1	4	7	7	6	3	6	0	4	5	5	5	52
	2	1	2	0	1	2	0	0	6	0	4	4	20
	3	0	0	2	1	3	3	0	0	0	0	2	11
TM	1	2	1	0	2	1	2	4	1	0	2	2	17
	2	1	0	0	0	0	0	3	0	0	0	0	4
	3	0	0	1	0	0	0	6	0	0	0	0	7
EACH SHIP	1	22	34	30	34	21	35	40	21	20	28	19	304
	2	10	15	5	4	17	9	20	23	5	12	15	133
	3	10	12	15	15	14	12	16	6	5	20	20	145

TABLE 4

NUMBER OF MEN AT EACH TECHNICAL PROFICIENCY CHECKOUT (TPC) LEVEL

Location No. 2

		SHIP										
RATING	TPC LEVEL	1	2	3	4	5	6	7	8	9	10	EACH RATING
EM	1	2	2	3	4	3	0	2	5	4	1	26
	2	2	0	1	1	1	2	1	1	1	1	11
	3	0	1	2	0	0	2	1	0	0	0	6
ET	1	3	5	5	3	5	5	7	7	2	3	45
	2	1	1	1	0	0	1	0	0	2	1	7
	3	0	0	0	1	0	0	0	0	1	1	3
FT	1	2	4	4	4	12	4	1	7	8	2	48
	2	1	0	2	1	2	2	2	3	1	1	15
	3	2	1	0	0	0	0	0	0	0	0	3
IC	1	0	0	2	0	1	0	0	0	2	1	6
	2	0	1	2	0	1	0	0	0	0	0	4
	3	0	1	0	0	2	2	0	0	0	1	6
RD	1	0	0	0	0	0	1	2	0	0	0	3
	2	0	0	6	4	0	1	4	6	0	5	26
	3	0	3	0	1	5	4	0	9	5	0	27
RM	1	3	3	4	1	7	2	0	0	0	0	20
	2	2	1	1	4	1	6	3	0	4	0	22
	3	0	0	0	0	0	0	3	0	1	5	9
ST	1	5	2	4	3	4	5	2	9	4	2	40
	2	0	2	0	2	0	1	0	0	1	1	7
	3	0	2	2	1	1	4	10	0	0	2	22
TM	1	0	0	0	0	2	1	0	1	0	1	5
	2	0	1	1	0	0	0	1	1	0	0	4
	3	0	0	1	0	0	1	0	0	0	0	2
EACH SHIP	1	15	16	22	15	34	18	14	29	20	10	193
	2	6	6	14	12	5	13	11	11	9	9	96
	3	2	8	5	3	8	13	14	9	7	9	78

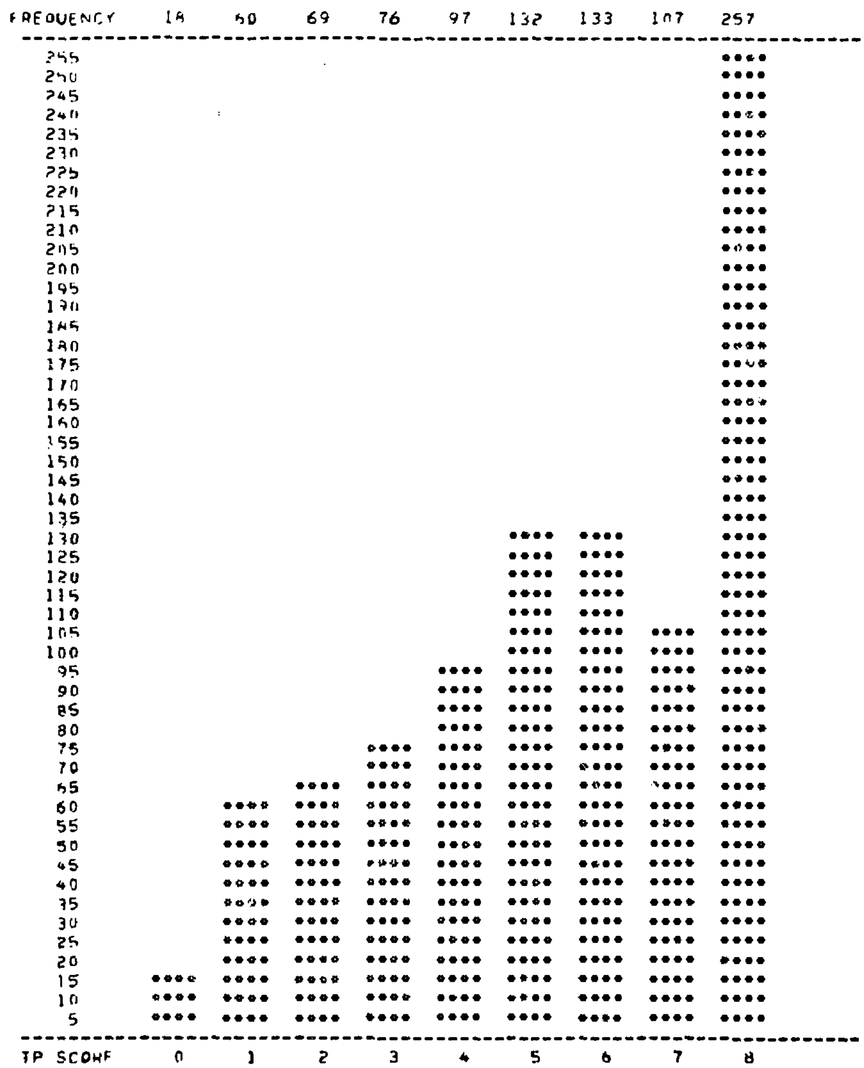

Fig. 5.--Histogram of Technical Proficiency Scores
(N = 949)

APPROACH

An approach to the statistical analysis of the data involved the selection of appropriate analyses within four general areas:

1. The validity of the performance estimators SRE, PRE, GRE, and WRE with respect to a selected criterion measure.

In order to determine the validity of the four performance estimators (SRE, PRE, GRE, and WRE) for predicting on-the-job performance of the electronics maintenance personnel involved in the research effort, the results of the TPCF were used as a criterion measure of absolute technician proficiency. The belief that the TPCF reflects the on-the-job performance of electronics maintenance personnel must rest to a large degree upon related results of prior research efforts. In particular, from references that were cited in the section Validation of Performance Estimators.

Initially, in order to determine the degree of association between the performance estimators (SRE, PRE, GRE, and WRE) and the selected criterion variable (TPC level), triserial correlation coefficients were developed by location. Due to the extreme skewness of the distribution of the underlying continuum (represented by TP score, see Figure 5), a test of normality of TP score was executed to determine the appropriateness of triserial correlation. This resulted in the choice of a curvilinear regression analysis as a better approach for validating the performance estimators by location and subsequently by rating with TP score as the continuous criterion measure.

2. An evaluation of technician job competency as determined or implied by the TPCF.

The appropriateness of the job tasks represented on the TPCF was approached by developing a frequency table of men CHECKED OUT and NOT CHECKED OUT by rating on each job task. The agreement of each job task to the hierarchial classification of the tasks provided some indication of the extent to which it was still applicable to electronic maintenance activities. A more detailed analysis of the TPCF that included the development of sample conditional and joint frequency tables allowed the development of a procedure for determining technician job competency within a rating. Furthermore, these analyses revealed areas of suggested modifications of the TPCF prior to its implementation.

3. Multiple comparisons between ratings or ships with respect to their average performance levels.

The approach employed in this report to develop comparisons between ratings and between ships was an additive model suggested by a two-way fixed effects analysis of variance with interaction. This required the selection of the appropriate variable, from among SRE, PRE, GRE, WRE, and TP score, upon which to base the comparisons. The variable selected was the one which best met the statistical requirements, i.e., normality of the variable, homogeniety of variances over the main effects, and independence of ship, rating, and cell observations.

4. Degree of association between various demographic variables and the performance variables.

From the demographic information collected on the Personnel Identification Information Form (PIIF), product-moment correlations between the demographic variables, and the performance estimators (SRE, PRE, GRE, WRE, and TP score) were developed. This same approach was applied to each of the eight job activities in order to determine if any job activity related to a particular demographic variable.

These areas are the most rewarding in the sense that they would provide some insight into the merits of the performance measurement technique being researched and of the implications for its application within the U. S. Navy.

RESULTS AND DISCUSSION

Validity of the Performance Estimators

Triserial Correlation Analyses

Initially sample mean reliabilities were developed for each of the four performance estimators (SRE, PRE, GRE, and WRE) for each TPC level. The mean reliability values are the average values of the performance estimators in the TPC levels, therefore, the mean values would be expected to be smaller for a lower proficiency level. The results of this phase of the statistical analysis are presented in Table 5 for technicians at those ships sampled at Location No. 1, Location No. 2, and combined locations.

Employing the results of Table 5, triserial correlation coefficients were developed between each of the performance estimators (SRE, PRE, GRE, and WRE) and Technical Proficiency Checkout (TPC) level for technicians sampled at each location and combined locations. Table 6 presents the resulting triserial correlations.

Comparing the locations, particularly with respect to the SRE, PRE, and GRE, only the triserial correlation coefficients for data collected at Location No. 2 agree with Siegel and Federman's prior results [16]. This observation required a consideration of the appropriateness of triserial correlation to the data collected in this project.

Application of the triserial correlation coefficient involves the following requirements:

a) the segmented variable is basically continuous and normally distributed; and,

b) all the segments which together would form a whole normal distribution are present.

Consider again the histogram in Figure 5. Recall that the variable, Technical Proficiency score (TP score), was segmented into one of three levels of technician proficiency. This histogram represents the entire distribution of the segmented variable, which may be taken as continuous and is clearly negatively skewed. A

TABLE 5

MEAN RELIABILITIES

Location No. 1

TPC LEVEL	N	Mean Reliabilities in Each TPC Level			
		SRE	PRE	GRE	WRE
1	303	.351	.597	.931	.657
2	134	.331	.553	.919	.566
3	145	.427	.625	.923	.557

Location No. 2

TPC LEVEL	N	Mean Reliabilities in Each TPC Level			
		SRE	PRE	GRE	WRE
1	193	.361	.629	.947	.642
2	96	.213	.380	.928	.557
3	78	.141	.338	.878	.502

Combined Locations

TPC LEVEL	N	Mean Reliabilities in Each TPC Level			
		SRE	PRE	GRE	WRE
1	496	.355	.608	.937	.651
2	230	.283	.483	.923	.562
3	223	.328	.524	.907	.538

TABLE 6

TRISERIAL CORRELATION ANALYSES

		Performance Estimators			
	N	SRE	PRE	GRE	WRE
Location No. 1	582	-0.090*	-0.015	0.031	0.256*
Location No. 2	367	0.340*	0.335*	0.235*	0.335*
Combined Locations	949	0.061	0.122*	0.099*	0.283*

*Significantly different from zero at the α = .05 level.

goodness of fit test for normality [5] was applied to the distribution of TP scores of the 949 technicians. This test statistic will be called the g_1 test statistic.[7]

When the g_1 test statistic was applied to the sample data of TP scores, the resulting test statistic values were

$$g_1 = -.5123, \qquad \text{implying } z = 6.4632.$$

Therefore, the assumption of normality for TP scores must be rejected for the sample data collected on the population of electronics maintenance personnel (949 technicians in the sample).

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[7]The g_1 test statistic is given by $g_1 = \dfrac{\sqrt{N}\,\sum(X - \bar{X})^3}{[\sum(X - \bar{X})^2]^{3/2}}$

where X represents an observation, $\bar{X}$ the sample mean, and N is the sample size. If the null hypothesis is that the underlying distribution is normal,

then it has been shown [5] that $z = g_1 \sqrt{\dfrac{(N + 1)\,(N + 3)}{6(N - 2)}}$

is approximately normal with mean zero and variance one. In fact a test of the hypothesis that the underlying distribution is normal (at the α = .05 level of signficance) is given by:

reject the null hypothesis of normality if
z is greater than 1.96 or less than -1.96.

This particular goodness of fit test has several advantages over the usually applied Kolmogorov-Smirnov tests or the well known Chi-square tests in that, in particular, the population mean and standard deviation need not be known and the test need not be applied just to large samples. Furthermore, this test is more sensitive to departures from normality due solely to skewness than the other two tests [5].

The g_1 test statistic was also applied to the distribution of TP scores at either location. The test statistic values were $g_1 = -.4930$, $z = -4.8810$ and $g_1 = -.5473$, $z = -4.3156$ at Location No. 1 and Location No. 2 respectively. Therefore, at both locations the assumption of normality of TP scores must be rejected. These results were verified by the histograms of TP scores for those locations. In both cases these histograms demonstrated the negative skewness of the distribution of TP scores.

<u>Curvilinear Regression Analysis</u>

Essentially due to the non-normality of the TP scores, an alternate analysis was employed in order to determine the degree of association between the predictor variables (SRE, PRE, GRE, and WRE) and criterion variable (TP score). The particular procedure to be employed to achieve this end was a curvilinear multiple regression procedure outlined in Cooley and Lohnes [3]. A few remarks on this subject for the purposes of this report have been provided in Appendix G.

Appendix H provides the results of the analyses of these predictor and criterion variables for the total of 949 technicians sampled. Similar results as found in Appendix H were also developed for Location No. 1 and Location No. 2. Although those printouts are not presented in this report, the essential information from those printouts is given in Table 7[8] along with the essential information from Appendix H.

Consider Table 7 and the evaluation of SRE as a predictor of TP score for the two locations combined. The product-moment correlation between SRE and TP score is .055 (not significantly different from zero at the $\alpha = .05$ level). In attempting to fit a linear, quadractic, and cubic model to the data of SRE values and TP scores, the multiple correlation coefficient (R^2) values were .003, .007, and .043 respectively. However, in view of the fact that the residual mean square does not change from the linear to cubic model, it would be just as well to chose the linear model (particularly since R^2 for the cubic equation is not significantly larger than .007). Therefore, from Appendix H, the best regression equation is

$$\text{TP score} = 5.219 + 0.397 \text{ SRE}.$$

Because SRE and TP score are essentially independent, the best estimate of SRE will always be the mean of the observed TP scores, regardless of the observed SRE. This result is further reflected in noticing that the sample mean TP score is 5.350, approximately equal to 5.219 - the TP score intercept of the regression line.

Observing the results of Table 7 for the predictor variables PRE and GRE on the two locations combined, only minimal improvement can be made with these estimates over the SRE. In fact the GRE is almost identical to the SRE and for practical purposes cannot be held to possess significant merit. The PRE is modestly better with a correlation of .1. However, for the PRE, the highest R^2 value does not even reach .05, a long way from a perfect fit with an R^2 value of 1.0. Based upon this analysis, PRE must be termed only slightly better than the SRE and GRE.

The WRE provides the most promising and consistent (over locations) estimator of the four predictors considered. It is most promising in the sense that it provides

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[8] All of the computer printouts on the curvilinear regression procedure employed in this report are in terms of "centered data." This technique improves the computation of the printout values by minimizing roundoff errors. Therefore, when reviewing the results of Table 7, one must be concerned with the relative magnitude of the residual mean square in attempting to fit a linear model versus fitting a higher order model.

TABLE 7

CURVILINEAR REGRESSION ANALYSES BY LOCATION†

Location No. 1

Predictor Variable	r_{xy}	Linear R^2	Linear s^2	Quadratic R^2	Quadratic s^2	Cubic R^2	Cubic s^2
SRE	-.069	.005	.002	.007	.002	.072	.002
PRE	-.009	.000	.002	.043	.002	.047	.002
GRE	.024	.001	.002	.003	.002	.004	.002
WRE	.242*	.058	.002	.058	.002	.062	.002

Location No. 2

Predictor Variable	r_{xy}	Linear R^2	Linear s^2	Quadratic R^2	Quadratic s^2	Cubic R^2	Cubic s^2
SRE	.288*	.083	.003	.083	.003	.090	.003
PRE	.277*	.077	.003	.078	.003	.100	.002
GRE	.212*	.045	.003	.047	.003	.052	.003
WRE	.292*	.085	.003	.085	.003	.089	.003

Locations Combined

Predictor Variable	r_{xy}	Linear R^2	Linear s^2	Quadratic R^2	Quadratic s^2	Cubic R^2	Cubic s^2
SRE	.055	.003	.001	.007	.001	.043	.001
PRE	.100*	.010	.001	.036	.001	.036	.001
GRE	.087*	.008	.001	.008	.001	.009	.001
WRE	.257*	.066	.001	.066	.001	.071	.001

†$R^2 = r_{xy}^2$ in the linear case.

*Significantly different from zero at the $\alpha = .05$ level.

r_{xy} = product-moment correlation coefficient between the predictor variable x and the criterion variable y (TP score).

R^2 = multiple correlation coefficient.

s^2 = residual mean square

the highest product-moment correlation coefficient with the selected criterion variable, TP score. However, it cannot be said that it better fits the data than any of the other three estimators with respect to the three types of curves considered.

The curvilinear regression for the predictor variable WRE, Appendix H, page H-6, indicates that a linear curve is the best fit to the data. The regression equation is given by

$$\text{TP score} = 3.571 + 2.95\ \text{WRE}.$$

In comparison to the other estimators the WRE can be said to possess moderate validity at best for appraising an absolute level of technician performance. As such its application to the population of electronics maintenance personnel is tenuous.

Analyzing the results at either location again points out the differences between the results obtained at either location. However, this is due mainly to a difference in r_{xy} values and not to R^2 values for goodness of fit of the linear, quadratic, and cubic models from one location to the next. This may be due to the high degree of unexplained criterion variance in the data at either location and with respect to the locations combined. Scatterplots of the data in those three cases with respect to each predictor variable verified the high degree of dispersion in the data and the lack of any obvious pattern or functional relationship in those plots.

Within Rating Analyses

A factor that may influence the frequency with which a population does not work at a particular job activity is, of course, the appropriateness of the job activity to present-day electronic maintenance activities. The most homogeneous type of subpopulation that would reflect most members of the subpopulation working at the same job activities should be rating. It is mainly for this reason that the subpopulations considered in this report are ratings, and not, for example, ships within locations which should (and did) reflect results similar to those found in Appendix H. In order to perform the most general type of analysis to determine the validity of the performance estimates, a curvilinear regression analysis as previously discussed and employed in Appendix H was applied per rating for each of the four predictor variables - SRE, PRE, GRE, and WRE. Appendix I gives the resulting 32 printouts of the Cooley and Lohnes [3] curvilinear regression analysis. The object is to select for each rating, the best of three possible curves - linear, quadratic, and cubic - for each performance estimator which best fits the data in terms of significantly larger multiple correlation coefficients for smaller residual mean squares. Comparisons between the performance estimators may then be made by performing an appropriate test of hypothesis of the equality of two correlation coefficients (or multiple correlation coefficients). The test that is usually applied is the "Fisher's z" test which employes the asymptotic distribution of the sample correlation coefficient. However this test requires that the distributions of the underlying populations are bivariate normal (see Anderson [1], page 78). Because the distribution of TP scores and the SRE, PRE, and GRE were not normally distributed with respect to the individual ratings, the appropriateness of employing this test is in question. Furthermore the literature seems to be vacant of a discussion of the robustness of the test. Therefore the approach must be in terms of comparing the observed sample product-moment correlations, and, in particular, on the amount of criterion variance explained by the variables. This approach will not necessarily produce a statistically significantly different performance estimator but one which is a more promising estimator, in terms of the sample information.

The following outline represents the essential results of the curvilinear regression analyses presented in Appendix I. The results are presented by rating in Tables 8 through 13 together with observations and recommendations.

TABLE 8

EM CURVILINEAR REGRESSION ANALYSES (N = 97)

Predictor Variable	r_{xy}	Linear R^2	Linear s^2	Quadratic R^2	Quadratic s^2	Cubic R^2	Cubic s^2
SRE	.355*	.133	.009	.136	.009	.176	.009
PRE	.247*	.061	.010	.133	.009	.113	.009
GRE	.301*	.090	.010	.154	.009	.221	.008
WRE	.492*	.242	.008	.254	.008	.300	.008

*Significantly different from zero at the $\alpha = .05$ level.

1. EM rating - Clearly the estimator WRE demonstrates the best fit to the data. The product-moment correlation of .492 indicates at least a fair degree of association of the WRE with the technician's absolute performance level. (Although the R^2 value is significantly better for the cubic curve over the other two curves, the value of .300 in that case can only indicate a moderate fit of the cubic curve to the data.

$$\text{TP score} = 4.849 - 15.571\ \text{WRE} + 44.319\ \text{WRE}^2 - 26.561\ \text{WRE}^3.$$

The other estimators do not demonstrate a better fit to the data than the WRE. In view of this and other considerations (e.g., the examination of the scatterplots), the WRE is recommended for application in this rating for those situations in which the probability of effective performance of an individual in the EM rating is required.

TABLE 9

ET CURVILINEAR REGRESSION ANALYSES (N = 173)

Predictor Variable	r_{xy}	Linear R^2	Linear s^2	Quadratic R^2	Quadratic s^2	Cubic R^2	Cubic s^2
SRE	.318*	.101	.005	.142	005	.142	.005
PRE	.366*	.134	.005	.135	.005	.135	.005
GRE	.508*	.258	.004	.266	.004	.271	.004
WRE	.445*	.198	.005	.209	.005	.210	.005

*Significantly different from zero at the $\alpha = .05$ level.

2. ET rating - For this rating two significant estimators arise, the GRE and WRE. The WRE is still a promising estimator even though it has a lower product-moment correlation than the GRE (.445 versus .508) and does not fit the data as well. The GRE values may be spurious observations for this rating for it is not significantly higher in any other rating. However, without evidence of this fact it is recommended that either the GRE or WRE be employed in this rating. Furthermore, the values of the product-moment correlations for those estimators reflect at least a moderate degree of association with TPCF results.

Because the R^2 values do not change appreciably from one type of curve to the next, it is recommended that the linear model be employed for prediction purposes in either case. The linear curves are:

TP score = 2.99 + 4.08 GRE, and

TP score = 4.344 + 3.79 WRE.

TABLE 10

FT CURVILINEAR REGRESSION ANALYSES (N = 154)

Predictor Variable	r_{xy}	Linear R^2	Linear s^2	Quadratic R^2	Quadratic s^2	Cubic R^2	Cubic s^2
SRE	.346*	.119	.006	.120	.006	.120	.006
PRE	.265*	.070	.006	.100	.006	.104	.006
GRE	.374*	.140	.006	.148	.006	.165	.006
WRE	.430*	.185	.005	.200	.005	.204	.005

*Significantly different from zero at the α = .05 level.

3. FT rating - This rating again illustrates that the WRE is the most promising estimator. In fact it is almost identical to the results obtained for the ET rating and the WRE. The product-moment correlation of .43 reflects a moderate degree of association with the criterion variable. The R^2 value of near .2 still illustrates a significant degree of unexplained criterion variance in the data. It is again suggested that the linear model:

TP score = 3.366 + 4.635 WRE

be employed in this rating. The linear model fit is modest (R^2 = .185) but the WRE possesses sufficient promise to be called a good estimator of FT technician proficiency.

TABLE 11

IC CURVILINEAR REGRESSION ANALYSES (N = 58)

Predictor Variable	r_{xy}	Type of Curve					
		Linear		Quadratic		Cubic	
		R^2	s^2	R^2	s^2	R^2	s^2
SRE	.361*	.131	.016	.131	.016	.133	.016
PRE	.322*	.104	.016	.131	.016	.134	.016
GRE	.387*	.149	.015	.154	.015	.169	.015
WRE	.434*	.188	.014	.241	.014	.292	.013

*Significantly different from zero at the α = .05 level.

4. IC rating - Unfortunately the sample size (N = 58) for this rating is too low to place confidence in the obtained correlation coefficient. However, the WRE must be selected as the most valid estimator on all counts. The cubic model

$$\text{TP score} = -7.57 + 68.26\ \text{WRE} - 113.95\ \text{WRE}^2 + 63.03\ \text{WRE}^3$$

is suggested for use in this rating and is a moderate estimate of TP score. The residual mean square is high for this rating only because of the small sample size. In any event this rating reflects the general trend that we have been witnessing and, therefore, the WRE may be employed in this rating.

TABLE 12

RD CURVILINEAR REGRESSION ANALYSES (N = 139)

Predictor Variable	r_{xy}	Type of Curve					
		Linear		Quadratic		Cubic	
		R^2	s^2	R^2	s^2	R^2	s^2
SRE	-.168	.028	.007	.093	.007	.131	.006
PRE	-.215*	.046	.007	.046	.007	.093	.007
GRE	.021	.000	.007	.013	.007	.047	.007
WRE	-.051	.003	.007	.021	.007	.041	.007

*Significantly different from zero at the α = .05 level.

5. RD rating - None of the four estimators that have been discussed in this report should be employed in the RD rating. In part the failure of the estimators in this case must be attributed to the significantly high frequency with which individuals in this rating do not work at the job activities that were used on the evaluation forms.

TABLE 13

RM, ST, AND TM CURVILINEAR REGRESSION ANALYSES

		Type of Curve					
		Linear		Quadratic		Cubic	
Predictor Variable	r_{xy}	R^2	s^2	R^2	s^2	R^2	s^2
RM Rating (N = 137)							
SRE	.211*	.044	.007	.057	.007	.068	.007
PRE	.156	.024	.007	.028	.007	.031	.007
GRE	.041	.002	.007	.140	.006	.139	.006
WRE	.366*	.134	.006	.153	.006	.154	.006
ST Rating (N = 152)							
SRE	.199*	.040	.006	.069	.006	.069	.006
PRE	.058	.003	.007	.003	.007	.102	.006
GRE	.099	.010	.007	.134	.006	.178	.006
WRE	.234*	.055	.006	.080	.006	.123	.006
TM Rating (N = 39)							
SRE	.198	.039	.026	.129	.024	.217	.022
PRE	.243	.059	.025	.094	.025	.153	.024
GRE	.186	.035	.026	.035	.027	.085	.026
WRE	.403*	.162	.023	.177	.023	.224	.022

*Significantly different from zero at the α = .05 level.

6. Rating RM, ST, and TM - The results for these ratings are almost identical and can be discussed as a group. In every case the WRE is the best estimator of TP score. The product-moment correlations are low for the RM and ST ratings, and moderate for TM's. All of the R^2 values demonstrate a poor fit to the data, indicating an even higher degree of unexplained criterion variance than that found in the EM, ET, FT, and IC ratings. It is recommended that the cubic curve be employed in the ST and TM rating and a linear curve for the RM rating. The corresponding equations may be found from the computer printout of the curvilinear regression for those ratings (pages I-26, I-30, and I-34 respectively). However, the utility of their use as prediction instruments has not been convincingly demonstrated.

Technician Job Competency Evaluation

As hypothesized in the discussion on the validity of the performance estimators SRE, PRE, GRE, and WRE, the TPCF could be employed as a criterion measure of the absolute proficiency level of electronics maintenance personnel. That the TPCF possesses that characteristic was evaluated by Siegel and Fischl [17] for avionics technicians and at that time the TPCF possessed a substantial degree of promise. Siegel and Federman [16] applied the TPCF when appraising the proficiency level of electronics maintenance personnel and in evaluating the SRE, PRE, and GRE.

Due to the high degree of reliance on the TPCF as a criterion measure, it is well to investigate the TPCF and consider whether some of its properties seem to hold up for the data collected in this project. The appropriateness of the job tasks on the TPCF for present-day electronic maintenance activities can be considered, by rating. Furthermore, are the job tasks listed in the same hierarchial order as when originally developed? While it may not be possible to completely answer questions of this type, it is possible to give at least a partial answer based on the present format of the TPCF. By using the properties of the TPCF it is possible to develop a competency level for technicians in each rating and determine whether a particular rating may be performing at a certain proficiency level.

Job Task Analyses

The reader will recall that the job tasks listed on the TPCF are ordered with Job Task No. 1 being the easiest and Job Task No. 8 the most difficult. The following is a list of the job tasks as found on the TPCF:

Task Description

(easiest)

1. Capable of employing safety precautions.
2. Capable of replacing most of unit's equipment.
3. Capable of removing most of unit's equipment.
4. Capable of following block diagrams.
5. Capable of knowing relationship of equipment to other related equipment.

6. Capable of calibrating most of unit's equipment.

7. Capable of trouble-shooting/isolated malfunction(s).

(most difficult) 8. Capable of employing electronic principles involved in maintenance.

Table 14 is the frequency of occurrence of men CHECKED OUT and NOT CHECKED OUT by rating over the eight job tasks without reference to their performance on other job tasks. For example, of the 97 men in the EM rating, 95 were CHECKED OUT on Job Task No. 1, 87 were CHECKED OUT on Job Task No. 2, ..., and 55 were CHECKED OUT on Job Task No. 8. Similarly, for the other ratings.

From Table 14 the hierarchial difficulty of tasks is generally represented in the EM, ET, FT, IC, ST, and TM ratings. This is evidenced by the fact that one would expect progressively fewer men to complete a more difficult task. Except for the ST rating, Job Task No. 6 - Capable of calibrating most of this unit's equipment with which his rating is concerned - seems out of place in that fewer individuals are CHECKED OUT on this task than the next more difficult task, Job Task No. 7. In fact the better position for Job Task No. 6 would be after Job Task No. 8. In that case the job tasks would follow more closely a hierarchial classification.[9]

In any event it can be said that Job Task No. 6 is no longer of such prominence as originally thought. This is a result of the introduction of more sophisticated electronic equipment aboard ships in recent years. This equipment frequently consists of integrated circuitry and compact electronic modules requiring little if any calibration. Furthermore, test instrumentation calibration is also in demise because less test equipment is being employed. Normally a defective component is replaced en toto without regard aboard ship for finding the particular fault in the component. Those functions are beyond normal shipboard electronic maintenance activities.

In the RD rating there are a significant number of individuals NOT CHECKED OUT on many of the tasks. This is probably due more to a nonapplicability of those tasks to that rating than to a lack of sufficient training. This is to a degree verified by the findings in Appendix E where it was demonstrated that for most job activities there are a very high proportion of individuals in that rating who either do not work at the job activities or received $\Sigma UE = 0$ and $\Sigma UI = 0$ from their supervisor. It is possible that the nonapplicability of many of the tasks to the RD rating did give erroneous TP scores for this rating and depressed the validity coefficients (see Table 12). A more detailed study than the present one would be required to come to a definite conclusion on this issue.

As shown in Table 14 and the RM rating, Job Tasks 2 and 4 are not in agreement with the underlying order of job tasks, but Job Task No. 6 is in a proper position for this rating. It seems that a reordering of the first five job tasks on the TPCF would allow this instrument to be more applicable to this rating. It would probably require a minor research effort to revise the tasks in the RM rating.

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[9]It is important to note that none of the conclusions of previous sections would be altered with this modification because the TP score (or TPC level) is independent of the hierarchial classification. Those variables are dependent only upon the number of job tasks an individual was CHECKED OUT on, and not upon the order of the CHECKED OUT tasks.

TABLE 14

JOB TASK ANALYSES

	EM Frequencies (N = 97)							
Job Task No.	1	2	3	4	5	6	7	8
Checked Out	95	87	87	77	75	43	63	55
Not Checked Out*	2	10	10	20	22	54	34	42
	ET Frequencies (N = 173)							
Job Task No.	1	2	3	4	5	6	7	8
Checked Out	168	147	164	165	126	96	129	132
Not Checked Out	5	26	9	8	47	77	44	41
	FT Frequencies (N = 154)							
Job Task No.	1	2	3	4	5	6	7	8
Checked Out	148	125	134	143	116	93	100	102
Not Checked Out	6	29	20	11	38	61	54	52
	IC Frequencies (N = 58)							
Job Task No.	1	2	3	4	5	6	7	8
Checked Out	57	45	49	44	41	26	33	27
Not Checked Out	1	13	9	14	17	32	25	31
	RD Frequencies (N = 139)							
Job Task No.	1	2	3	4	5	6	7	8
Checked Out	136	27	38	50	97	8	8	26
Not Checked Out	3	112	101	89	42	131	131	113
	RM Frequencies (N = 137)							
Job Task No.	1	2	3	4	5	6	7	8
Checked Out	135	88	100	88	113	46	27	13
Not Checked Out	2	49	37	49	24	91	110	124
	ST Frequencies (N = 152)							
Job Task No.	1	2	3	4	5	6	7	8
Checked Out	144	118	119	117	121	103	77	80
Not Checked Out	8	34	33	35	31	49	75	72
	TM Frequencies (N = 39)							
Job Task No.	1	2	3	4	5	6	7	8
Checked Out	38	31	32	31	34	14	18	8
Not Checked Out	1	8	7	8	5	25	21	31

*The reader is cautioned that a score of NOT CHECKED OUT on a task does not differentiate between whether a technician really cannot be trusted with doing the task on his own without direct supervision or whether he was given a score of NOT CHECKED OUT because he does not work at that task.

Conditional Frequencies for Job Tasks

Appendix J provides tables of a more detailed analysis of some observations on the TPCF. In particular the Job Task Conditional Frequency is given by rating; i.e., for a given task, the number of individuals who were CHECKED OUT on each easier task given they were at most CHECKED OUT on the given task. Those tables should provide more insight into the hierarchial classification of the job tasks and also a relative level of technician competency by rating.

To illustrate the use of the tables prepared in Appendix J, consider Table 15. This table represents the Job Task Conditional Frequencies for the EM rating as can be found in Appendix J, page J-4.

TABLE 15

EM RATING CONDITIONAL FREQUENCIES (N = 97)

Job Task							
8	7	6	5	4	3	2	1
55	46	33	50	50	50	52	55
	17	4	13	14	17	17	17
		6	6	5	5	4	6
			6	5	6	6	6
				3	3	3	3
					6	5	6
						0	0
							2

The number of men that were not checked out on any job task is 2.

From the first row of Table 15, 55 of the 97 EM's were CHECKED OUT at most on Job Task No. 8. Of those 55 men, 46 were also CHECKED OUT on Job Task No. 7 (the next easier task), 33 were CHECKED OUT on Job Task No. 6, ..., and finally all 55 men were CHECKED OUT on Job Task No. 1 (the easiest task). Continuing, from the second row of the Conditional Frequency table, 17 of the 97 EM's were CHECKED OUT at most on Job Task No. 7 (i.e., none of those 17 men were CHECKED OUT on Job Task No. 8). Again, of those 17 men, 4, 13, 14, 17, 17, and 17 were also CHECKED OUT on Job Task No.'s 6, 5, 4, 3, 2, and 1 respectively. Finally, only 2 men were CHECKED OUT on Job Task No. 1, i.e., none of those 2 men were CHECKED OUT on a more difficult task. Also, there were 2 men in the EM rating that were not CHECKED OUT on any of the eight tasks. Clearly then one would expect any row of a Conditional Frequency table to contain almost identical entries, i.e., if the job tasks are truly hierarchial and representative of tasks in that rating.

Consider now Appendix J, page J-4, and the Conditional Frequency table. From the first two rows of that table, most of the EM's CHECKED OUT at most on Job Tasks 7 and 8 were also able to complete the easier tasks, except for Job Task No. 6. Again, that task is very much out of place in the order of job tasks. There is a low degree of incompetence present for 13 percent of the EM's could be CHECKED OUT at most on no more than Job Task No. 4. However, it must be realized that this result could also be due to the possibility that many of those individuals simply do not work at a more difficult task than Job Task No. 4.

The ET, FT, ST, and TM ratings (Appendix J, pages J-5, J-6, J-10, and J-11 respectively) demonstrate practically the same results for the Conditional Frequency tables as the EM's. For those ratings 8, 10, 9, and 13 percent were CHECKED OUT at most on no more than Job Task No. 4 respectively. The IC, RD, and RM ratings demonstrated 21, 30, and 17 percent. These remarks illustrate the practicality of the TPCF as an instrument for evaluating the competency level of particular ratings and for isolating those job tasks requiring further training by electronic maintenance technicians.

It is to be noted that as in the EM rating, Job Task No. 6 is inconsistent in most of the other ratings with respect to its proper order in the eight job tasks.

Joint Frequencies for Job Tasks

Appendix J also provides the Job Task Joint Frequencies by rating. For each rating this is the number of individuals who were CHECKED OUT on any two given tasks. Use of the Joint Frequency tables is illustrated by Table 16.

TABLE 16

EM RATING JOINT FREQUENCIES (N = 97)

1	2	3	4	5	6	7	8
95	87	87	77	75	43	63	55
	87	84	73	70	40	63	52
		87	71	69	40	62	50
			77	69	40	56	50
				75	42	56	50
					43	35	33
						63	46
							55

From the first row of Table 16, 95 of the 97 EM's were CHECKED OUT on Job Task No. 1, 87 (of the 97 EM's) were CHECKED OUT on both Job Task No.'s 1 and 2, 87 were CHECKED OUT on Job Task No.'s 1 and 3, ..., and 55 (Of the 97 EM's) were CHECKED OUT on Job Task No.'s 1 and 8. Similarly, from row 2 of the Joint Frequency table, 87 (of the 97 EM's) were CHECKED OUT on Job Task No. 2, while 84, 73, 70, 40, 63, and 52 (of the 97

EM's) were CHECKED OUT on both Job Task No. 2 and Job Task No. 3, 4, 5, 6, 7, and 8 respectively. It is well to note that the diagonal entries of this table corresponds exactly to the frequency entries for the CHECKED OUT case given in Table 14.

Just as in Table 15 on the Conditional Frequencies one would expect that any row of that table to have almost identical frequencies, in a Joint Frequency table one would expect any column to contain identical frequencies. For example, completion of Job Task No. 5 should also insure completion of Job Tasks 1, 2, 3, and 4. Likewise, the rows of the Joint Frequency tables should illustrate decreasing frequencies for being CHECKED OUT on a task does not insure being CHECKED OUT on a more difficult task.

From the Joint Frequency tables (Appendix J, pages J-4, J-5, J-6, J-7, and J-11) for the EM, ET, FT, IC, and TM ratings respectively, the previously mentioned patterns that are illustrated by a Joint Frequency table are demonstrated except for Job Task No. 6. This is consistent with the analysis on the Conditional Frequency tables. The ST rating conforms almost exactly to the expected patterns for a Joint Frequency table. Unfortunately there are a few instances in which the Conditional Frequency table for that rating deviates from the expected pattern. In any event the task descriptions on the TPCF are very descriptive of the ST rating job tasks.

The RD rating Joint Frequencies (page J-8) illustrate the general lack of patterns characteristic of a Joint Frequency table. The RM rating Joint Frequencies (page J-9) more closely conform to the desired patterns but still leave something to be desired.

Multiple Comparisons of Ships and Ratings

From either a research or applied point of view it is often necessary to compare the performance levels of various ships or ratings. Such comparisons may be employed to compare ships (or ratings) relative to mean performance levels. However, such comparisons can also offer a basis upon which to formulate a decision as to whether a particular ship configuration of men and/or equipment is, or is not, detrimental to ship/rating performance. In a similar fashion, policy making decisions also can be evaluated with respect to their influence on the performance of ships or ratings affected by that policy.

In this section the main subject of concern will be the development and justification of a technique for performing pairwise comparisons between ratings and between ships on the basis of mean performance levels with respect to some variable. The variables to be considered are the SRE, PRE, GRE, WRE, and the selected criterion variable TP score. In general this subject falls under the area of multiple comparisons arising from an Analysis of Variance (AOV) of ship/rating effects. The particular model[10] to be considered will be a two-way fixed effects design with an unequal number of observations for the ship/rating

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[10] It is assumed that each observation y_{ijk} on the k^{th} individual in the i^{th} ship in the j^{th} rating is due to an overall effect (μ), a ship effect (α_i), and a rating effect (β_j). Furthermore, a general model addresses the question of the existence of significant row-column interaction (δ_{ij}) upon each observation. In particular this report addresses the additive model of the form

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \delta_{ij} + e_{ijk}$$

where e_{ijk} is an error term associated with the above model. In this situation it is a two-way fixed effects design with an unequal number of observations in the i-j^{th} cell.

combinations (see Table 1). Choice of this model requires the verification of normality of the selected performance variable over the main effects, homogeneity of the variances of the main effects and independence across and between the main effects.[11] The main effects are "ships" and "ratings." That performance variable to be selected for performing the multiple comparisons will, most naturally, be the one which best conforms to the requirements for use of the model being considered and is most associated with technician on-the-job performance.

Distributional Properties of the Performance Estimators

The g_1 test statistic for normality was applied to the distribution of SRE, PRE, GRE, and WRE values for the 949 technicians in the sample (combined locations). Table 17 illustrates the results of this analysis.

TABLE 17

g_1 TEST STATISTIC VALUES FOR THE PERFORMANCE ESTIMATORS

	SRE	PRE	GRE	WRE
g_1	.5807	-.4565	-4.7092	.7939
z	7.3265	-5.7599	-59.4129	-.5823*

*Because WRE scores (Figure 4) are almost normally distributed, a test statistic [4] similar to the g_1 test statistic but more sensitive to departures from normality due to kurtosis was applied to the WRE scores.

Recall that rejection of normality results if $|z| \geq 1.96$.

Clearly then the only estimator which appears to be normally distributed is the WRE. This same analysis was applied by location and rating with practically the same results. In each case only WRE scores proved to be normally distributed, except for isolated incidents of the other estimators. This characteristic of WRE scores is not surprising as this situation is essentially an application of the Central Limit Theorem as found in probability theory, see [12]. The lack of normality on the part of the other estimators is not necessarily an undesirable feature, but it is true that this exercise does point out yet one more desirable feature of the WRE, namely, its general normality.

Choice of a Variable

As previously noted it is necessary to choose an appropriate variable upon which to base the multiple comparisons of ships and ratings. From the previous section - Distributional Properties of the Performance Estimators - it was observed that WRE scores possessed the unique characteristic among the performance variables (SRE, PRE, GRE, and TP score) of being normally distributed. This characteristic of WRE scores is most helpful particularly since homogeneity of variances in the ships, ratings, and

[11] A search of the literature failed to locate a particular test to employ for independence in the case of unequal numbers for the ship/rating combinations. See Anderson [1] for the case of equal numbers.

An identical AOV was executed as above but for the four ratings (EM, ET, FT, and IC) for which the performance measurement technique was most promising. Table 19 reflects the results of this AOV.

TABLE 19

AN ANALYSIS OF VARIANCE FOR 21 SHIPS AND 4 RATINGS

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Total	482	192.0419		
Between Ships	20	2.669	.1334	3.884*
Between Rating	3	.5621	.1874	5.4598*
Ship by Rating Interaction	60	4.0437	.0674	2.2975*
Residual	398	11.6747	.0294	

*Indicates significance at the α = .05 level.

In either of the above two AOV tables there exists significant ship/rating interaction. This situation will not permit the comparing of any two of the main effects under a two-way design because of the confounding of the main effects with the interaction terms. The only recourse is to test for significant differences in each ship, across ratings, or in each rating, across ships. If the interaction terms were not significant, it would be an easy matter to compare ratings and to compare ships by employing the entire set of data represented in the AOV's of Table 18 or Table 19, see again Scheffe [15].

Testing for Significant Ship (Rating) Effects for a Particular Rating (Ship)

In order to develop comparisons between ships (for a fixed rating) and to develop comparisons between ratings (for a fixed ship), this report will employ an AOV model[13] resulting from a one-way fixed effects design with unequal numbers of observations across the main effects. Homogeneity of the variances across the main effects must be assumed in this case for the usual tests are large sample tests and inapplicable for ship/rating numbers less than ten (see Layard [14] and Table 1).

For present purposes only the AOV's, and subsequent multiple comparisons, will be developed on the 21 ships participating in the project and the four ratings EM, ET, FT, and IC. This will involve 25 different AOV's to be constructed and subsequently developed for multiple comparison of the main effects if the AOV indicates significant main effects.

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[13]This report will employ a model of the form

$$Y_{ijk} = \mu + \alpha_i + e_{ijk} \qquad (j \text{ is fixed and } i=1, \ldots, 21)$$

for testing for significant ship effects, and a model of the form

$$Y_{ijk} = \mu + \beta_j + e_{ijk} \qquad (i \text{ is fixed and } j=1, \ldots, 4)$$

for testing for significant rating effects. The subscript k is an index representing the k^{th} man in that main effect.

Initally the hypothesis of equality of mean WRE scores was tested for the four ratings EM ,ET, FT, and IC for each of the 21 ships. This hypothesis was accepted for 12 of the 21 ships. On the remaining 9 ships Scheffe's multiple comparison technique was applied in searching for a possible significant difference between any two (of the four) ratings on the basis of mean WRE scores. Table 20 reflects the results of these multiple comparisons, each derived from a separate Analysis of Variance. (The resulting 21 AOV tables are too extensive to be presented in this report).

Finally the hypothesis of equality of mean WRE scores was tested for the 21 ships for each of the four ratings EM, ET, FT, and IC. This hypothesis was rejected for each of the four ratings. No significant differences were found between any pair of the ratings using Scheffe's multiple comparison technique. This is not an inconsistent result, for this could be a result of trying to perform too many multiple comparisons (therefore, increasing the comparison error rate) and/or the effect referenced in the footnote of Table 20.

TABLE 20

MULTIPLE COMPARISON OF FOUR RATINGS ON NINE SHIPS*

Ship	Highest Mean WRE			Lowest Mean WRE
a	EM	FT	ET	IC
b	FT	ET	EM	IC
c	EM	ET	IC	FT
d	ET	FT	EM	IC
e	IC	EM	ET	FT**
f	IC	ET	FT	EM**
g	FT	IC	EM	ET
h	EM	ET	IC	
i	EM	ET	FT	

*For each ship a line under two ratings signifies no significant difference between the ratings.

**It is important to note that while no differences in rating means were detected, the rejection of the null hypothesis of the equality of rating means is not in error. This only implies that some contrast other than those contrasts testing rating differences lead to that rejection, see Ferguson [8, pp. 279-283].

Association Between Demographic and Performance Variables

Usually it is of interest from either a research or applied point of view to estimate school success, final grade, etc. of an individual in some training program or school by employing such predictor variables as the Basic Test Battery (BTB) scores - GCT, ARI, MECH, and CLER scores or combinations of those scores. Typically BTB scores are used to predict actual school success which in turn is viewed as being the best available measure of potential job success. Seldom, however, are direct measures of on-the-job performance available as those developed in the current study. Accordingly the relationship between the BTB scores - GCT, ARI, and Skill (GCT + ARI) - and measures of on-the-job performance - SRE, PRE, GRE, WRE, and TP score - was investigated.

Besides the BTB scores, other available predictor variables were also considered under the general heading of demographic variables. In this report the demographic variables to be considered are: months known by supervisor, months on current job assignment, GCT score, ARI score, SKILL (GCT + ARI) score, and A, B, and C school final grade. The performance variables that will be employed to relate to on-the-job technician performance are the eight reliability ratios relative to the job activity factors on the JPQ ANSWER SHEET, and the variables SRE, PRE, GRE, WRE, and TP score.

Utility of Demographic Variables in Performance Prediction

In order to determine the utility or effectiveness of the demographic variables previously introduced to relate or be associated with on-the-job technician performance, product-moment correlation coefficients were developed between those demographic variables and the performance variables. From this analysis it is possible to infer the extent which the demographic variables may be viewed as linear predictors of the demographic variables.

Demographic Variable Prediction on Combined Locations

Table 21 reflects the product-moment correlation coefficients that resulted when the 949 technicians were considered. In that table there are many product-moment correlation coefficients significantly different from zero, but they are of such low magnitude. Now from a linear prediction standpoint, the multiple correlation coefficient (R^2) is related to the product-moment correlation coefficient (r_{xy}) by $R^2 = r_{xy}^2$. (x is one of the demographic variables and y is a performance variable.) Therefore, from Table 21, even for the largest r_{xy} value observed,[14] namely 0.217, the R^2 value for this case is still a very low 0.047 for the degree of fit of the linear model to the data (x is SKILL score and y is TP score). However, even with the low correlations represented by the BTB scores, those scores do offer some hope of predicting on-the-job performance as measured by the TPCF. The correlation coefficients reflect the degree of association that is typically found between predictor variables and on-the-job performance. However, these results show considerable promise for further research in the area of the development of on-the-job performance measures.

Demographic Variable Prediction in the EM, ET, FT, and IC Ratings

In a similar manner product-moment correlation coefficients were developed between the demographic and performance variables for the technicians sampled from the four more promising ratings EM, ET, FT, and IC. In Table 22 are the results of this analysis. From this table the same observations as above can be made for this case since no product-moment correlation is greater than 0.217, the largest previously observed. Also, as in the above, some hope is offered by BTB scores for predicting on-the-job performance as measured by the TPCF. The correlation coefficients, though suppressed, are still of sufficient magnitude to warrant some promise for further research.

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[14]Excluding B school final score which has such a low sample size represented.

TABLE 21

DEMOGRAPHIC CORRELATIONS ON EIGHT RATINGS

	N	Reliability Ratios							
		Ref Mat	Equip Op	Cir Anal	Pers Rel	Elec Safe	Inst	Elec Rep	Elec Cog
Mo known by super	948	0.032	0.068*	-0.006	-0.020	0.038	0.001	-0.069*	-0.036
Mo on current assign	948	0.029	0.106*	-0.005	-0.034	0.057	-0.013	0.012	-0.009
GCT scores	909	-0.027	-0.034	-0.048	-0.078*	-0.014	-0.096*	-0.050	-0.076*
ARI scores	909	0.018	-0.014	-0.030	-0.086*	-0.031	-0.076*	-0.039	-0.022
SKILL scores	909	-0.006	-0.029	-0.046	-0.095*	-0.027	-0.100*	-0.052	-0.057
A school final grade	774	0.089*	0.090*	0.046	0.038	0.017	0.082*	0.104*	0.101*
B school final grade	16	-0.022	0.379	0.227	0.231	0.178	0.323	-0.044	0.300
C school final grade	264	0.016	0.077	0.006	0.000	-0.054	-0.009	0.119	0.079

	N	Performance Estimators				
		SRE	PRE	GRE	WRE	TP Score
Mo known by super	948	-0.029	-0.038	0.055	0.011	0.086*
Mo on current assign	948	0.067*	0.036	0.044	0.070*	0.191*
GCT scores	909	-0.119*	-0.100*	-0.040	0.018	0.186*
ARI scores	909	-0.076*	-0.066*	-0.013	0.037	0.193*
SKILL scores	909	-0.111*	-0.095*	-0.034	0.032	0.217*
A school final grade	774	0.142*	0.096*	0.084*	0.098*	0.070*
B school final grade	16	0.339	0.387	0.167	0.265	-0.173
C school final grade	264	0.041	0.027	0.047	0.092	0.091

*Significantly different from zero at the α = .05 level.

TABLE 22

DEMOGRAPHIC CORRELATIONS ON FOUR RATINGS

	N	Reliability Ratios: Ref Mat	Equip Op	Cir Anal	Pers Rel	Elec Safe	Inst	Elec Rep	Elec Cog
Mo known by super	481	-0.043	-0.021	-0.097*	-0.055	0.025	-0.085	-0.062	-0.084
Mo on current assign	482	-0.035	0.093*	-0.034	-0.044	0.064	0.032	0.081	-0.019
GCT scores	459	-0.045	-0.001	0.026	-0.072	-0.047	-0.013	0.008	-0.007
ARI scores	459	-0.002	0.014	0.026	-0.094*	-0.035	0.006	-0.008	0.032
SKILL scores	459	-0.026	0.007	0.030	-0.093*	-0.046	-0.003	0.001	0.014
A school final grade	383	0.086	0.107*	0.047	0.009	0.057	0.063	0.067	0.088
B school final grade	10	-0.342	0.322	0.103	0.129	-0.201	0.328	-0.225	0.250
C school final grade	164	0.004	0.051	-0.057	0.016	-0.103	-0.097	-0.018	0.085

	N	Performance Estimators: SRE	PRE	GRE	WRE	TP Score
Mo known by rater	481	-0.083	-0.096*	-0.005	-0.040	0.089*
Mo on current assign	482	0.017	0.014	0.088*	0.062	0.214*
GCT scores	459	-0.050	-0.081	0.008	0.065	0.172*
ARI scores	459	-0.033	-0.056	0.016	0.048	0.144*
SKILL scores	459	-0.047	-0.077	0.014	0.064	0.178*
A school final grade	383	0.071	0.049	0.112*	0.125*	0.167*
B school final grade	10	0.028	0.213	-0.010	0.027	-0.265
C school final grade	164	-0.003	-0.045	-0.019	0.080	0.135

*Significantly different from zero at the α = .05 level.

SUMMARY AND CONCLUSIONS

Summary of Data Analyses

Evaluation of the Performance Estimators

When evaluating a performance estimator it is initially of interest to consider the degree to which that estimator does in fact measure an individual's on-the-job performance. In order to address this particular aspect of the analyses it was necessary to choose an appropriate criterion measure of on-the-job performance. The variable selected as the criterion measure in this report was Technical Proficiency (TP) score (or Technical Proficiency Checkout (TPC) level) as derived from the Technical Proficiency Checkout Form (TPCF). Prior research efforts demonstrated that this variable was a viable criterion variable. Initially triserial correlation coefficients were developed between the TPC level and each of the performance estimators (SRE, PRE, GRE, and WRE) being evaluated. Essentially due to the lack of normality of the continuous variable TP score, triserial correlation had to be considered inappropriate for the data collected in the course of this project. Finally a curvilinear regression analysis was executed between each of the performance estimators and TP score with an emphasis upon a least-squares interpretation of the corresponding results.

When the entire sample of 949 technicians was considered, relatively low multiple correlation coefficients corresponding to a linear, quadratic, and cubic model were obtained. Furthermore, low product-moment correlation coefficients were obtained for some estimators. Due to these results it was decided that a more appropriate approach to analyzing the data would be an analysis by rating. That is also a more appropriate approach for job tasks or job activities would be more homogeneous within a particular rating.

When the individual ratings were considered it could be concluded that of the four performance estimators - SRE, PRE, GRE, and WRE - the WRE possesses the greatest degree of promise in all ratings. The only exceptions occur for the ET and RD ratings in which the GRE is slightly better and none of the estimators apply, respectively. The WRE is a moderate estimate of absolute technician performance in the EM, ET, FT, and IC ratings and a modest estimate of absolute performance in the RM, ST, and TM ratings. It is recommended that the WRE be applied, in particular, upon the EM, ET, FT, and IC ratings for purposes of comparing individuals or groups of individuals in those ratings. In fact, it is suggested that in most analyses where the performance of an individual, or group of individuals in those ratings is needed, (i.e., an estimate of the probability of effective performance is required) that the WRE be employed. Usually these analyses would involve a classification or discrimination of such individuals on the basis of their present-day on-the-job performance. However, use of the WRE in the RM, ST, and TM ratings is not as justified and, therefore, if used in those ratings, it should be only with utmost caution with regard to its low validity, as determined by the TPCF.

The Criterion Measure of On-the-Job Performance

Because the TPCF was employed as a criterion measure of technician on-the-job performance, an analysis of the extent to which its properties were verified by the data collected in this project was considered. To achieve this end Conditional and Joint Frequency tables were developed by rating to determine whether the hierarchial classification of the job tasks was in effect and whether the job tasks were appropriate to present-day electronic maintenance activities. Results from those tables revealed that only one job task - capable of calibrating most of this unit's equipment with which his rating is concerned - was more dated than the other job tasks. With this exception the job tasks seemed to follow a hierarchial classification in all but the RM rating, and to a lesser degree in the RD rating. From these analyses it is suggested that the following alterations be completed by a potential user before the TPCF is employed either in an operational or research context:

1. An updating of the job task descriptions by rating. It is not likely that a list of task descriptions can be developed that are characteristic of the population of electronics maintenance personnel without being too general and not specific enough for their intended use in any rating.

2. A verification of the hierarchial classification of the updated task descriptions by rating.

3. Revision of the TPCF to include an answer column that would reflect whether the technician actually works at the task description being considered.

4. Development of alternative test statistics that would reflect the hierarchial classification of the job tasks which TP score does not do. Suggested random variables to consider are:

X = the highest job task the technician is CHECKED OUT on, or

Y = (X + TP score)/2.

Use of X in a rating is most warranted if the hierarchial classification is correct; if not, use of Y will "average" the effects of X and TP score.

5. A validation by rating that the TPCF is highly predictive of on-the-job performance for that rating.

In conclusion it can be said that the TPCF represents the most promising of the performance instruments evaluated. It is certainly the most easily administered and offers the least amount of confusion to the evaluator. Furthermore, the possibility of deriving competency levels from the Conditional Frequency tables offers an alternative procedure for comparing ratings or groups of technicians within a rating on the basis of the proportion of individuals CHECKED OUT at most on a certain task. Although such comparisons were not attempted in this report, it certainly is an appropriate topic for future research on the TPCF.

Comparisons Between Ships and Ratings

Multiple comparisons between ratings and between ships was accomplished in this report by means of appropriate fixed-effect additive Analysis of Variance (AOV) models. Use of these models required the homogeneity of variances across the main effects (ships and/or ratings), normality of the variable upon which the comparisons are to be based, and independence of the observations across ships and ratings. The performance variable selected, from among SRE, PRE, GRE, WRE, and TP score, was that one which best conformed to the above requirements and could be most associated with technician on-the-job performance. Initially this involved the investigation of the distributional properties of each of the performance variables. The distributions of the variables SRE, PRE, GRE, and TP score were all shown to be non-normal for the subpopulations considered. This characteristic of those variables is only detrimental in AOV analyses for the case of unequal number of observations for the ship-rating combinations, which was the case for the data collected in this report (see Table 1). Essentially the difficulty arises when one attempts to apply a test of homogeneity of variances for the variable considered. The standard tests for homogeneity of variance require normality of the variable considered.

Only the variable WRE could be termed normally distributed for all the subpopulations considered. Furthermore, it was shown to be the most promising type of performance estimator, particularly in the EM, ET, FT, and IC rating. In view of these and other related considerations it was the most optimal choice of a performance variable upon which to base the multiple comparisons. Unfortunately, not all the requirements for use of the AOV models to be employed were satisfied by the WRE, however, the techniques employed to that end demonstrate the procedures that one should go through in order to validly apply the AOV models.

Initially a two-way fixed effects design was applied to the data. However, because significant interaction was found to exist between ships and ratings, this necessarily forced multiple comparisions between ships (ratings) to be performed for a fixed rating (ship). Twenty-five AOV's were executed in that event in order to detect significant mean WRE scores between the four more promising ratings (EM, ET, FT, and IC) for each of the 21 ships in the project and between the 21 ships for each of these four ratings. No particular pattern seemed to emerge across ships as to which rating is more proficient (in terms of mean WRE scores). Furthermore, no pairwise significant difference was detected between any two ships (for any of the four ratings).

In conclusion it would seem that the WRE is the most appropriate performance variable upon which to base the multiple comparison of ships and ratings. However, it would be a valuable exercise for a user to also include the other candidate performance variables and choose that variable most appropriate to the characteristics of the data collected. Likewise, the application of the appropriate variable for particular ship-rating configurations may yield insignificant ship-rating interaction, thus eliminating some of the difficulties encountered in this report. In particular it is the user's responsibility to test the requirements and various configurations before deciding on a particular technique for performing multiple comparisons. It is hoped that the procedure employed in this report offers some guidelines to the potential user for application of the performance measurement technique being researched.

Analysis of Demographic Data

In addition to the performance data collected on the TPCF and JPQ ANSWER SHEET, demographic data were collected by means of the Personnel Identification Information Form (PIIF). The demographic variables that were subsequently studied were: months known by rater, months on current job assignment, GCT and ARI scores, and A, B, and C school final grades. Product-moment correlation coefficients were developed between those variables and the SRE, PRE, GRE, WRE, TP score and each of the eight job activity reliability ratios. Although the resulting correlations were low, some hope was offered by GCT and ARI scores for predicitng on-the-job performance as measured by $\overline{TP}$ scores. It is felt that further research in this area may reveal that Basic Test Battery scores have some utility for predicting job performance levels.

Observations on the Use of Composite Reliability Values

It will be observed that many of the analyses chosen for analyzing the data rest upon the particular characteristics observed in the data, e.g., distributional properties of the data. This is a reasonable and preferred procedure to follow in order to form an opinion based on the data collected. However, there was one necessary, and artificial, revision of the fundamental characteristics of the original data that was required in order to arrive at a numeric estimate of performance based on the estimators SRE, PRE, GRE, and WRE. That revision, of course, involved the adoption of a convention to estimate technician performance for those cases in which the technician either does not work at a job activity or received $\Sigma UE = \Sigma UI = 0$. The choice of a composite reliability value (Appendix F) to estimate technician performance in those cases cannot be viewed as the most optimal choice. However, it is certainly a reasonable and efficient means of employing the original data in order to achieve performance estimates in those cases. Reasonable in the sense that this estimate is derived as the individual job activity reliability ratios are derived, i.e., by totaling the number of UE's and UI's observed and forming the ratio $\Sigma UE/[\Sigma UE + \Sigma UI]$. Therefore, it should be no less objectional than are the reliability ratios. Furthermore, it is efficient in the sense that no complicated mathematical procedure is required in order to derive the composite reliability values.

The composite reliability values were derived by location (Table F-2) and it was those values which were subsequently employed throughout the remainder of the analyses. A better procedure would have been to derive a composite reliability value for the total of N = 949 technicians and employ those values for subsequent analyses rather than by the use of "per location" composite reliability values. However, as can be observed in Table F-2, the composite reliability values do not differ significantly by location except in two cases: Job Activity No. 7 in the RD rating and Job Activity No. 3 in the TM rating.

Effect of the Convention on the Performance Estimates SRE, PRE, and GRE

The Convention in the RD Rating

For the RD rating the composite reliability value is 0.0 for Job Activity No. 7 at Location No. 2 (Table F-2). However, at Location No. 2 the RD's received SRE = PRE = 0.0 (see p. 3 and footnote 2) because all (but one) RD at that location either did not work at Job Activity No. 7 or received $\Sigma UE = \Sigma UI = 0$ (see Table E-1). In addition to the low SRE and PRE scores resulting from the use of this convention at Location No. 2, it must be pointed out that low scores were likewise recorded for the TPCF at that location (Table 4). This effect would result in a high degree of association between the predictor and criterion variables for the RD rating at Location No. 2 because low predictor scores are corresponding to low criterion scores. This situation, however, is unique to the RD rating at Location No. 2.

At Location No. 1 the situation of a high degree of association between the predictor and criterion variables was not illustrated for the RD rating. As at Location No. 2, most of the RD technicians are in the lowest TPC levels (Table 3) and <u>every</u> RD at Location No. 1 did not work at Job Activity No. 7 or received $\Sigma UE = \Sigma UI = 0$ (Table E-1). However, all the composite reliability values are high for Location No. 1 (see Table F-2) implying that most likely the SRE and PRE are different from zero and of a large magnitude. This characteristic of the SRE and PRE would imply an inconsistency with the low TPC levels recorded at Location No. 1. Namely, an inverse relationship has been created at Location No. 1 essentially due to the convention that was adopted. That is, high predictor scores correspond to low TPCF scores in the RD rating, whereas at Location No. 2, low predictor scores are associated with low TPCF scores. It may be said that this effect at Location No. 1 has significantly contributed to the low correlation values that were subsequently calculated (see Tables 6 and 7). However, in terms of composite reliability values, the correlations are most correct at Location No. 1. Only at Location No. 2, where as previously noted, there is an inconsistency in the composite reliability values, were the performance estimators, SRE, PRE, and GRE able to correspond to the low TPC levels and, thus, incidentally, produce higher correlations. Therefore, the correlations obtained at Location No. 1 probably reflect the most accurate portrayal of the use of composite reliability values.

The Convention in Other than the RD Rating

Now except for the extreme case mentioned above in the RD rating, all other composite reliability values in Table F-2 are high. This is in close agreement with the TPCF results (Tables 3 and 4) for the EM, ET, FT, and IC ratings. The distribution of TPC levels for those ratings demonstrate a high concentration of individuals in the highest level of technical proficiency. On the other hand, in the RM, ST, and TM ratings, the distribution of TPC levels is uniform or demonstrate a higher concentration of technicians in the lowest level of technical proficiency, but the composite reliability values are high.

Now it is difficult to generalize as to how the above observations are reflected in the estimators SRE, PRE, GRE, and WRE for association with TPCF results. This depends on the frequency with which the composite reliability values are used (Table E-1). However, it seems true that the greater the frequency of use of the composite reliability value the less agreement of the TPCF with the reliability estimators.

Observations on the Use of Composite Reliability Values

As with any convention one employs, there seems to be a degree of artificiality in the composite reliability values, for it would probably be easy to select a convention, by rating perhaps, which would allow the estimators to have a significant degree of promise in all ratings. This, of course, is a most inappropriate means by which to evaluate an estimator. However, results of this research effort seem to indicate that it is not the use of <u>any</u> convention that is posing difficulty, but rather its overuse. As discussed in Appendix E, there were 42 (out of 164) rating-job activity combinations where the convention had to be employed on at least one-third of the technicians in some job activity and rating. Such a high use of a convention can only force the individual performance estimates (in particular the SRE, PRE, and GRE) to more reflect the effect of the convention rather than individual performance.

This observation is further reinforced with the WRE by the frequency with which it must employ the convention. This estimator only employs the convention for the case in which the technician received $\Sigma UE = \Sigma UI = 0$. The case in which the technician did not work at the job activity is ignored by this estimator. Table K-1 reflects the improvement in nonuse of the convention. It is believed that in no small way does considering only the job activities a technician works at and then appropriately weighting those to form a reliability value permit a greater reflection of individual performance and subsequently a greater degree of association with the TPCF.

Conclusions

In conclusion the more promising estimator of electronic maintenance performance as a function of uncommonly effective and uncommonly ineffective performance incidents is a performance estimator similar to the Weighted-Average Reliability Estimate (WRE). This conclusion is made under the assumption that composite reliability values are employed in those job activities in which a man does not work at or received $\Sigma UE = \Sigma UI = 0$. However, even this estimator cannot be recommended for general use within the U. S. Navy at the present time. Only in the EM, ET, FT, and IC ratings is its use presently warranted, while application in the RM, ST, and TM ratings is tenuous. It is suggested that before this estimator is employed in other ratings that the appropriate job task analysis and isolation of job activity factors be completed before a validation effort is attempted in that rating, perhaps similar to the procedures conducted in this report. That it is necessary to perform a validation effort was illustrated in this research effort by the results obtained in the RD rating. It would seem that it is too much to assume that the technique can be automatically applied to other ratings with even similar job activities.

Finally, the results of this research effort do demonstrate that the performance measurement technique being researched does have a large degree of potential for practical application on specific ratings within the U. S. Navy. In particular, the detailed analyses of the Technical Proficiency Checkout Form (TPCF) demonstrated the potential of that instrument to isolate job tasks which may require further training on the part of some technicians. Likewise the Job Performance Questionnaire can also be employed to isolate those individuals of potential detrimental performance levels in terms of excessive uncommonly ineffective incidents of performance. Even though such instruments are completed by the technician's immediate supervisor, as opposed to an unbiased evaluator, those positive qualities of the performance measurement instruments can prove to be most valuable even if one is not interested in deriving an estimate of the probability of effective performance for the technician evaluated. Therefore, short of a procedure which allows for a completely unbiased evaluator, the technique must be given credit for being perhaps the most viable performance measurement technique presently available and of being of greatest potentital value to the U. S. Navy.

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APPENDIX A

PERFORMANCE EVALUATION INSTRUMENTS

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JOB PERFORMANCE QUESTIONNAIRE

Name of Supervisor__________________________ Rating______ Ship or Unit_______

Instructions to Supervisor. The purpose of this form is to determine the number of effective and ineffective performances you have observed among your men during the past two months. We are only interested in the ***uncommonly effective*** and the ***uncommonly ineffective*** performances.

List below the names of all the men under your supervision who are currently striking for, or in any of the following ratings: DS, EM, ET, FT, IC, MT, RD, RM, ST, TD, TM (AE, AT, AQ, AX). If you supervise more than one of these ratings, please use a separate form for each rating.

Now, considering the fleet electronic maintenance objectives, enter your estimate of the number of uncommonly effective (UE) and uncommonly ineffective (UI) performances during the past two months for each man being rated. Please refer to the definitions lists for the meanings of the JOB ACTIVITIES and of the OBJECTIVES involved.

The first line has been filled in as an example. The supervisor completing the example felt that Peter Smith had ten unusually effective performances and two unusually ineffective performances while performing ***Electronic Circuit Analyses*** when considered against the objectives of fleet electronic maintenance. He also felt that Smith showed two uncommonly effective performances in the area of ***Electrosafety*** and four uncommonly ineffective performances in ***Instruction.***

If a man has ***not*** had an opportunity to perform in a particular area, enter a dash (-); if he has had an opportunity but has not shown any uncommonly effective or ineffective performances, enter a zero (0).

JOB ACTIVITIES	Using Reference Materials		Equipment Operation		Electronic Circuit Analysis		Personnel Relationships		Electrosafety		Instruction		Electrorepair		Electrocognition	
Name and rating	UE	UI	UE	UI	UE	UI	UE	UI	UE	UI	UE	UI	UE	UI	UE	UI

NAME OF MAN EVALUATED ______________________

NAME OF SUPERVISOR ______________________ PATING/RATE ____________

DATE __________ SHIP OR UNIT __________ LOCATION ____________

JPQ ANSWER SHEET

REMINDER: WHEN TYPING LAYOUT, PLEASE MAKE SURE THE RIBBON IS IN GOOD CONDITION SO THAT YOU WILL HAVE A SHARP, DARK COPY FOR BETTER REPRODUCTION.

Using Reference Materials

(a) UE		(b) UI		(c)
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	
5	5	5	5	
6	6	6	6	
7	7	7	7	
8	8	8	8	
9	9	9	9	

Equipment Operation

(a) UE		(b) UI		(c)
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	
5	5	5	5	
6	6	6	6	
7	7	7	7	
8	8	8	8	
9	9	9	9	

Electronic Circuit Analysis

(a) UE		(b) UI		(c)
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	
5	5	5	5	
6	6	6	6	
7	7	7	7	
8	8	8	8	
9	9	9	9	

Personnel Relationships

(a) UE		(b) UI		(c)
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	
5	5	5	5	
6	6	6	6	
7	7	7	7	
8	8	8	8	
9	9	9	9	

Electro-safety

(a) UE		(b) UI		(c)
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	
5	5	5	5	
6	6	6	6	
7	7	7	7	
8	8	8	8	
9	9	9	9	

Instruction

(a) UE		(b) UI		(c)
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	
5	5	5	5	
6	6	6	6	
7	7	7	7	
8	8	8	8	
9	9	9	9	

Electro-repair

(a) UE		(b) UI		(c)
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	
5	5	5	5	
6	6	6	6	
7	7	7	7	
8	8	8	8	
9	9	9	9	

Electro-cognition

(a) UE		(b) UI		(c)
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	
5	5	5	5	
6	6	6	6	
7	7	7	7	
8	8	8	8	
9	9	9	9	

QUESTIONS

(d)	(e)	(f)
1	1	1
2	2	2
3	3	3
4	4	
5		

Supervisor's Social Security No.

0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9

Technician's Social Security No.

0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9

FOR OFFICE USE ONLY

Sq.	Ship	Ind. No	TPC
	0	0	
	1	1	
	2	2	
	3	3	
	4	4	
	5	5	
	6	6	
	7	7	
	8	8	
	9	9	

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TECHNICAL PROFICIENCY CHECKOUT FORM

NAME OF SUPERVISOR________________________ RATING/RATE______________

FULL NAME OF MAN EVALUATED____

SHIP OR UNIT______________ LOCATION______________ DATE______________

TASK DESCRIPTION	CHECKED OUT	NOT CHECKED OUT
1. Capable of employing safety precautions on most of this unit's equipment with which his rating is concerned.	☐	☐
2. Capable of replacing most of this unit's equipment with which his rating is concerned.	☐	☐
3. Capable of removing most of this unit's equipment with which his rating is concerned.	☐	☐
4. Capable of following block diagrams for most of this unit's equipment with which his rating is concerned.	☐	☐
5. Capable of knowing relationship of equipment to other related equipment with which his rating is concerned.	☐	☐
6. Capable of calibrating most of this unit's equipment with which his rating is concerned.	☐	☐
7. Capable of trouble-shooting/isolated malfunction(s) in most of this unit's equipment with which his rating is concerned.	☐	☐
8. Capable of employing electronic principles involved in maintenance of most of this unit's equipment with which his rating is concerned.	☐	☐

MAKE CERTAIN THERE IS AN "X" IN A BOX OPPOSITE EACH TASK DESCRIPTION

REMINDER: WHEN TYPING LAYOUT, PLEASE MAKE SURE THE RIBBON IS IN GOOD CONDITION SO THAT YOU WILL HAVE A SHARP, DARK COPY FOR BETTER REPRODUCTION.

PERSONNEL IDENTIFICATION INFORMATION FORM (PIIF)

NAME OF SUPERVISOR ____________________ RATING/RATE ____________

DATE __________ SHIP OR UNIT ____________ LOCATION ____________

DIRECTIONS

Use a #2 pencil only. Blacken the answer rectangle completely. Cleanly erase answers you want to change. Erase any stray marks. 'TECHNICIAN' is the man being evaluated.

In the boxes just below, print as much as possible of the TECHNICIAN'S NAME. Start with his last name, print one letter to a box. Leave one box blank, then print his first name; leave another box blank, then his middle name, etc.

a	a	a	a	a	a	a	a	a	a	a	a
b	b	b	b	b	b	b	b	b	b	b	b
c	c	c	c	c	c	c	c	c	c	c	c
d	d	d	d	d	d	d	d	d	d	d	d
e	e	e	e	e	e	e	e	e	e	e	e
f	f	f	f	f	f	f	f	f	f	f	f
g	g	g	g	g	g	g	g	g	g	g	g
h	h	h	h	h	h	h	h	h	h	h	h
i	i	i	i	i	i	i	i	i	i	i	i
j	j	j	j	j	j	j	j	j	j	j	j
k	k	k	k	k	k	k	k	k	k	k	k
l	l	l	l	l	l	l	l	l	l	l	l
m	m	m	m	m	m	m	m	m	m	m	m
n	n	n	n	n	n	n	n	n	n	n	n
o	o	o	o	o	o	o	o	o	o	o	o
p	p	p	p	p	p	p	p	p	p	p	p
q	q	q	q	q	q	q	q	q	q	q	q
r	r	r	r	r	r	r	r	r	r	r	r
s	s	s	s	s	s	s	s	s	s	s	s
t	t	t	t	t	t	t	t	t	t	t	t
u	u	u	u	u	u	u	u	u	u	u	u
v	v	v	v	v	v	v	v	v	v	v	v
w	w	w	w	w	w	w	w	w	w	w	w
x	x	x	x	x	x	x	x	x	x	x	x
y	y	y	y	y	y	y	y	y	y	y	y
z	z	z	z	z	z	z	z	z	z	z	z

FINAL MARK

A School				B School				C School			
0	0	.0	0	0	0	.0	0	0	0	.0	0
1	1	.1	1	1	1	.1	1	1	1	.1	1
2	2	.2	2	2	2	.2	2	2	2	.2	2
3	3	.3	3	3	3	.3	3	3	3	.3	3
4	4	.4	4	4	4	.4	4	4	4	.4	4
5	5	.5	5	5	5	.5	5	5	5	.5	5
6	6	.6	6	6	6	.6	6	6	6	.6	6
7	7	.7	7	7	7	.7	7	7	7	.7	7
8	8	.8	8	8	8	.8	8	8	8	.8	8
9	9	.9	9	9	9	.9	9	9	9	9	9

CLASS STANDING

0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9

CLASS SIZE

0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9

Technician's Birthdate

Month	19__	
Jan		
Feb		
Mar	0	0
Apr	1	1
May	2	2
Jun	3	3
Jul	4	4
Aug	5	5
Sep	6	6
Oct	7	7
Nov	8	8
Dec	9	9

Technician's Months

Known by Supervisor		on Current Job Assignment	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

Technician's Months of Active Duty Service

USN		USNR	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

Technician's

Rating	Paygrade
EM	E-1
ET	E-2
FT	E-3
IC	E-4
RD	E-5
RM	E-6
ST	E-7
TM	E-8
	E-9

GCT		ARI		MECH		CLER		Yrs. Ed.	
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9

Technician's Social Security No.

0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	3	9	9

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DESCRIPTION OF JOB ACTIVITIES

JOB ACTIVITY — DESCRIPTION

1. Using Reference Materials--includes the following type of activities:
   a. use of supporting reference materials
   b. making out reports
2. Equipment Operation--includes the following type of activity:
   a. operating equipment, electrical and electronics test equipment, and other electronic equipments
3. Electronic Circuit Analysis--includes the following type of activities:
   a. understanding the principles of electronic circuitry
   b. making out failure reports
   c. keeping records of maintenance usage data
4. Personnel Relationships--includes the following type of activity:
   a. supervising the operation, inspection, and maintenance of electronic equipments
5. Electro-safety--includes the following type of activity:
   a. using safety precautions on self and equipment
6. Instruction--includes the following type of activity:
   a. teaching others how to inspect, operate, and maintain electronic equipments
7. Electro-repair--includes the following type of activity:
   a. equipment repair in the shop
8. Electro-cognition--includes the following type of activities:
   a. maintenance and troubleshooting of electronic equipments
   b. use of electronic maintenance reference materials

MEANINGS OF FLEET ELECTRONICS MAINTENANCE OBJECTIVES

1. Readiness

To maintain efficiently self, subordinate personnel, equipment, and systems in state of readiness consistent with fleet requirements.

2. Performance

To complete any given mission in minimum time with appropriate level of accuracy and reliability.

3. Operation

To obtain optimum system output when equipment is operated, i.e., output characterized by precision and variability appropriate to mission.

4. Safety

To carry out duties with maximum protection for men and equipment consistent with mission.

5. Preparation

To prepare for personnel requirements of present and future equipment, systems, and situations through use of training programs, maintenance of high morale, etc.

APPENDIX B

DATA COLLECTION PROCEDURES

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PROCEDURE EMPLOYED IN DATA COLLECTION

The data collection effort originated by requesting of CINCPACFLT and CINCLANTFLT that ships (Destroyer-type vessels) and men (in the electronic maintenance ratings - EM, ET, FT, IC, RD, RM, ST, and TM) be considered for participation in this project. It was requested that initially a project coordinator at an appropriate fleet command be assigned in order to coordinate the efforts of the project researchers from NAVPERSRANDLAB and ship liaison officers. Favorable response from both fleet commands resulted in the assignment of the following project coordinators:

LCDR G. W. Dunne
Flag Secretary
Cruiser-Destroyer Flotilla Nine
FPO San Francisco, CA 96601
(located at the U.S. Naval
Station, San Diego, CA)

RDCS C. J. Masterson
COMCRUDESLANT Staff
CRUDESLANTFLT
FPO New York, N. Y.
(located at the U.S. Naval
Station, Newport, RI)

The duties and responsibilities of the project coordinator may be outlined as:

1. identifying the ships available for participating in the project.

2. seeking the assignment of a liaison officer (usually the senior electronics materials officer) aboard each available ship to coordinate the data collection aboard that ship.

3. scheduling the meetings between the ship liaison officers and the project researchers.

4. making appropriate checks on the progress of the data collection effort aboard each ship.

5. collection and reviewing for completeness of the data forms before mailing all forms to NAVPERSRANDLAB.

Once the project researchers had established the ships and liaison officers of those ships that were participating in the project, an initial meeting was arranged between the ship liaison officers and the project researchers. At this meeting the researchers explained the purpose of the project and outlined the duties and responsibilities of a ship liaison officer for completing the data collection effort aboard his ship. It was emphasized that it would be the ship liaison officers responsibility to perform all phases of the data collection effort aboard ship.

Each liaison officer was given a set of instructions (Appendix C) which outlines in detail the steps he was to perform in order to complete the data collection effort aboard his ship. Essentially it was required that the liaison officer select immediate supervisors of men involved in electronic maintenance activities in the EM, ET, FT, IC, RD, RM, ST, and TM ratings who may participate in the project. Each liaison officer was also given a set of Roster Forms (a sample of a Roster Form can be found in Appendix C, page C-8). One Roster Form was completed by the liaison officer for each supervisor participating in the project and it includes a list of the men the supervisor is to evaluate. A technician occurred on this list if that supervisor had been his immediate supervisor for at least the past two months, length of the evaluation period, and the technician at that time was at most a petty officer second class in one of the aforementioned ratings. In order to achieve the most reliable information and not to place too much of a burden on any one supervisor, the supervisor was limited to evaluating no more than seven men - the seven, or less men, he would be most knowledgable about with respect to their on-the-job performance.

At the second and final meeting, the Roster Forms were returned to the project researchers who gave a Xerox copy of these forms to the ship liaison officer and the project coordinator. Using the Roster Forms the project researchers completed packages of Performance Evaluation Forms, one such package for each supervisor. Each package contained a set of Instructions for the Supervisor for Completing Performance Forms (Appendix D), a Xerox copy of the appropriate Roster Form listing the men that the supervisor is to evaluate, and the appropriate number of sets of Performance Evaluation Forms (discussed in the section, Data Collection Instruments), one set for each technician the supervisor was to evaluate.

Upon returning to his ship, the liaison officer held a meeting with the supervisors to explain the purpose of the project and to describe how they were to complete the sets of Performance Evaluation Forms. Once the supervisors had completed their evaluations, the liaison officer submitted all forms to the Administrative Officer aboard his ship who provided the additional demographic information on the men evaluated. After this exercise the ship liaison officer returned all forms to the project coordinator. The project coordinator, once he received the completed forms from all the ships, mailed all forms to NAVPERSRANDLAB.

APPENDIX C

INSTRUCTIONS FOR
SHIP LIAISON OFFICER

NOTE: The instructions on pages C-3 thru C-12 (pages -1 thru -5 of the text of the instructions and pages -1 and -1 thru -4 for enclosures (1) and (2) respectively) of this report are paginated for publication. For economy of reproduction, the page numbers were not changed for this report.

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NAVAL PERSONNEL RESEARCH AND DEVELOPMENT LABORATORY
Washington, D. C.

Performance Evaluation Measures
Information to Ship Liaison Officers

Background

The general purpose of the present study is to further investigate an economical and practical method for providing feedback information regarding the readiness of Naval electronically oriented technical personnel (specifically EM, ET, FT, IC, RD, RM, ST, and TM ratings) for completing their assigned mission. Essentially, a result of the study may include the application of a performance evaluative technique which will allow continuous and quantitative answers to questions such as: What is the current level of effectiveness of the maintenance personnel in a given rating, ship, or squadron? How does the maintenance personnel effectiveness level of a given rating, ship, or squadron compare with that of other ratings, ships, or squadrons?

In a previous Office of Naval Research study, a unique performance measurement technique was developed which the Naval Personnel Research and Development Laboratory is now concerned with replicating in order to establish its validity and to determine the practicality of this concept. Basically, eight dimensions of the electronics maintenance ratings were defined: (1) using reference materials, (2) equipment operation, (3) electronic circuit analysis, (4) personnel relationships, (5) electro-safety, (6) instruction, (7) electro-repair, and, (8) electro-cognition. On the basis of a supervisor observing his men performing on the job, he indicates the number of times that he saw unusually effective or unusually ineffective performance demonstrated on each of the eight job dimensions. Based upon the estimates of unusually effective/ineffective behavior, meaningful measures of technician effectiveness can be established. Further, the individual technician effectiveness values can be further treated to form effectiveness indices for ratings, ships, and squadrons.

Because this effort is primarily concerned with replicating a prior study, any information provided by ship personnel will be used only for research purposes by the Naval Personnel Research and Development Laboratory and <u>only</u> to serve as a statistical data base for validating the results of that prior study. Furthermore, any comparisons made between ratings, ships, or squadrons will be used <u>only</u> for research purposes.

Suggested Ship Liaison Officer Assistance Plan

The steps outlined below are those as envisioned by the project researchers which you may execute in order to insure an efficient data collection effort aboard your ship.

Completion of the Roster Forms

Either a project researcher or the project coordinator at CRUDESLANT has given you a set of Roster Forms (enclosure (1)). To complete the Roster Forms you are to select men involved in electronic maintenance activities in the EM, ET, FT, IC, RD, RM, ST, and TM ratings and immediate supervisors of those men aboard your ship. Generally the men being evaluated will be petty officers second class and below. The supervisors may be either enlisted personnel or officers but must be the immediate supervisors of the men they are to evaluate. They should have known the men they are evaluating for at least the past two months. Not all supervisors of men in the previously mentioned ratings will qualify for participation in this project, however, it is desired that all individuals in the above ratings participate. Once you have completed the Roster Forms, go to each supervisor to participate in this project and have him verify that he is the immediate supervisor of the men that you have selected for him on the respective Roster Form.

Once the Roster Forms have been verified by the supervisors, send a copy of these forms to:

Mr. Bernard Rafacz
Naval Personnel Research
and Development Laboratory
Room 3315, Bldg. 200
Washington Navy Yard
Washington, D. C. 20390

He is your contact man at the Naval Personnel Research and Development Laboratory. If you have any problems or questions concerned with the implementation of the instructions, it may be possible for you to contact him (AUTOVON 288-4457) or the project coordinator.

He will prepare the packages of Performance Evaluation Forms for mailing to you. One such package is a blue folder containing a set of Instructions to the Supervisor on the left inside cover and sets of performance evaluation forms on the right. On the front of each package is a label with the name of the supervisor who is to complete the sets of performance evaluation forms contained therein on the men for whom he is their immediate supervisor.

Briefing Each Supervisor

Once you have received the Packages of Performance Evaluation Forms from the Naval Personnel Research and Development Laboratory, you are now ready to distribute these forms to the supervisors participating in this project. This may be done in one of two ways: 1) calling a meeting of all supervisors so that you may distribute the packages and brief them as to their responsibilities all at one time, or, 2) meet individually with each supervisor and instruct him on a personal basis as to his responsibilities in completing the experimental forms.

It is your choice as to which procedure to follow, however, for ships with only several supervisors participating, the latter method may be the most convenient.

When meeting with the supervisor you should instruct him on the same subject material as you were originally briefed either by the project researcher or the project coordinator at CRUDESLANT. In particular, you should guide the supervisor through his set of Instructions, going over the three SAMPLE pages of performance evaluation forms. Important things to mention to the supervisor about the three forms in each set of Performance Evaluation Forms are outlined below.

1. The Personnel Identification Information Form (PIIF)

The purpose of this form is to provide various background information on the man being evaluated. The supervisors should first of all supply the information at the top of this form. Only the background information to the right of the cross-hatched area is to be supplied by the supervisor. Please tell him that he must do this to facilitate the job of the Administrative Officer aboard his ship. Because he is normally in everyday contact with the men he is evaluating, it should not be too difficult to obtain this information directly from the man being evaluated. The information to the left of the cross-hatched area will be supplied by the Administrative Officer aboard your ship and so the supervisor should not concern himself with this section of the PIIF. If for some reason he cannot obtain some of the background information from the man being evaluated, please have the Administrative Officer supply this information at a later date. Particular instructions for completing this form are given in the Supervisor's Instruction Package. Please be sure that he understands these instructions and the correct procedure for entering the requested information on the blank PIIF Op-Scan Sheet in each set of experimental forms.

2. The Technical Proficiency Checkout Form (TPCF)

This form is designed to estimate the level of technical complexity at which a man is able to work without direct supervision. The supervisor should provide the information at the top of the TPCF. The eight task descriptions are listed in ascending order of difficulty with task No. 8 identified as the most difficult task. The supervisor is simply to record an "X" in the CHECKED OUT box for each task which he feels the ratee is capable of performing "on his own without direct supervision." Otherwise he should record an "X" in the NOT CHECKED OUT box. The supervisor must be certain there is an "X" in a box opposite each task description.

3. The Job Performance Questionnaire (JPQ) ANSWER SHEET

The JPQ ANSWER SHEET is undoubtedly the most difficult form we are asking the supervisor to complete. However, the researchers have tried to facilitate the understanding of what information is requested by giving explicit samples to each question to be answered. In particular the JPQ ANSWER SHEET records estimates of the total number of uncommonly effective (UE) and uncommonly ineffective (UI) incidents of performance the supervisor has observed over a prior two month period on the man being evaluated. Read page 7 of the Supervisor's Instructions aloud to every supervisor and be sure that he understands what he is expected to record on the JPQ ANSWER SHEET. At the top of page 9 is a definition of what is generally meant as an uncommonly effective or uncommonly ineffective performance However, the supervisor should not adhere strictly to this definition. He would best know for his particular working area what such performances are. He should use the researchers definition only as a guide to conceptualize upon the extremes of performance.

Page 13 of the Supervisor's Instructions is a SAMPLE of a JPQ ANSWER SHEET found in each set of performance evaluation forms. The supervisor must review the table on page 9 together with the sample in order to understand where and how to record his estimates of the total number of UE and UI incidents of performance on the JPQ ANSWER SHEET. Please review this table with him. Also remark on the NOTE at the bottom of page 9.

QUESTION (c) on page 11 of the Supervisor's Instructions must be answered in column (c) for each job activity. Please point this out to the supervisor.

Three remaining questions given on pages 11 and 12 of the Supervisor's Instructions are to be answered in the lower corner provided on the JPQ ANSWER SHEET. Finally the supervisor is to place his social security account number in the space provided on each JPQ ANSWER SHEET he completes.

Instruct the supervisor that he will have approximately one week to complete all forms for the men he is to evaluate. It is important that he realizes that the Op-Scan sheets (the PIIF and JPQ ANSWER SHEET) will be machine processed and therefore it is essential that they remain as much in their original condition as is possible. Once the supervisor completes the forms, he must return them to you in the original folder, as you submitted them to him. You should review the forms as they are submitted and check that all of the information that is requested has been provided. Please be sure that each form of each set contains the supervisors name and the technician's name in the proper locations.

4. Briefing the Administrative Officer

It is now necessary that you submit all packages to the Administrative Officer aboard your ship in order that the Personal Identification Information Form (PIIF) be completed for each man evaluated. Enclosure (2) is a set of Instructions for the Administrative Officer. You will have to request his assistance in order that the information to the left of the cross-hatched area on each PIIF be completed. All of this information may be found in the personnel jacket of the man being evaluated. Complete details for providing this information are contained within the Instructions to the Administrative Officer. To insure that the forms are properly completed, you should review these instructions with him.

Once the Administrative Officer has completed all the PIIFs and returned all packages to you, from each set of Performance Evaluation Forms remove the paper clip. (For Op-Scan purposes it is imperative that the forms are not bent.) All completed packages and any extra forms are to be given to the project coordinator. He will send them back to Mr. Rafacz at the Naval Personnel Research and Development Laboratory.

SAMPLE

ROSTER FORM

Name of Liaison Officer *LT George Merklin* Date *2 Jan 72*

Ship *USS ROAN* Homeport Location *Newport*

Immediate Supervisor *Abner Smith* Rating/Rate *EMC*

Names of Men to be Evaluated	Rating/Rate
Tom Henry Jones	*EM3*
George William Klack	*RMSN*
Robert Larry Lane	*ETN2*
etc.	*etc.*

Enclosure (1)

NAVAL PERSONNEL RESEARCH AND DEVELOPMENT LABORATORY
WASHINGTON, D.C.

Instructions for the Administrative Officer
Completing the Personnel Identification
Information Form (PIIF)

Recently your ship and some supervisors of men in the electronic or related ratings - EM, FT, ET, IC, RD, RM, ST, TM - aboard your ship have been selected to participate in a performance evaluation program being conducted by the Naval Personnel Research and Development Laboratory. The men selected are immediate supervisors of personnel in those ratings. The liaison officer aboard your ship in charge of coordinating the activities between the researchers and your ship for this program has given each such supervisor a package of materials containing a Supervisor's Instruction Package and sets of Performance Evaluation Forms; one set for each man the supervisor is evaluating. Every set of Performance Evaluation Forms is made up of the following forms:

1. Personnel Identification Information Form (PIIF)
2. Technical Proficiency Checkout Form (TPCF)
3. Job Performance Questionnaire (JPQ) ANSWER SHEET

The supervisor will complete in part a set of Performance Evaluation Forms for each man he is evaluating. Only the Personnel Identification Information Form (PIIF) found in each set is to be completed by the Administrative Officer. In essence, this form records various background information on the man being evaluated. Once the supervisor has completed supplying the information requested on the set of Performance Evaluation Forms, he will return them to the liaison officer who in turn will give them to you, the Administrative Officer, in order that the PIIF in each set be completed. For each PIIF you receive, the supervisor was to have supplied the information to the right of the cross-hatched area on this form. The first thing you should do is to check over this section of the form and see that all of the following information was provided for the man being evaluated:

a. Technician's Name
b. " Social Security Number
c. " Birthdate
d. " Months Known by Supervisor
e. " Months on Current Job Assignment
f. " Months of Active Duty Service (USN* and USNR**)
g. " Rating and Paygrade

*Record 99 months for USN if the Technician's Months of USN Active Duty Service equals or exceeds 99 months.

**Record 99 months for USNR if the Technician's Months of USNR Active Duty Service equals or exceeds 99 months.

Enclosure (2)

If some information in this section is omitted, please provide it. Use only a #2 pencil when supplying any information on this form. To aid you in completing the PIIFs, page 4 of these instructions contains a sample of a completed PIIF. From this sample you will see that the following information is obtained from the section of the form to the right of the cross-hatched area:

1. The supervisor is EMC Abner Smith located at Newport aboard the USS ROAN and completed this form on 7 January 1972.

2. This supervisor was evaluating EM3 Tom Henry Jones whose social security account number is 123-45-6789 and he was born in March, 1948. He was known for 13 months by the supervisor, and had been 15 months on his current job assignment. Jones had served no USNR active duty time but had been on USN active duty for 29 months.

One you have reviewed the sample on page 4 for that section, turn your attention to the section of the PIIF to the left of the cross-hatched area. The following table represents all of the information for this section that is to be provided by you from the service record for the man being evaluated.

	Item	Location in Service Record
Final Mark	A School	NAVPERS 601-4
	B "	"
	C "	"
Class Standing	A "	"
	B "	"
	C "	"
Class Size	A "	"
	B "	"
	C "	"
Years of Civilian Education (Yrs. Ed.)		NAVPERS 601-3
GCT Score		"
ARI "		"
MECH "		"
CLER "		"

In all cases the most recently completed A, B, or C school information is to be provided. If for some reason a technician did not attend some of the schools, leave that section of the PIIF blank for that school. A Final Mark such as 54.23 is recorded as 54.23 on the PIIF. Final Marks of the form, 90, 82, 77, etc., (i.e., two digit scores) are recorded as 90.00, 82.00, 77.00, etc., respectively. If some schools gave a Final Mark of "satisfactory" or "unsatisfactory", record 99.99 for a satisfactory Final Mark and 00.01 for an unsatisfactory Final Mark.

Once again turn to page 4 of these instructions which contains the previously mentioned sample of a PIIF and to the section to the left of the cross-hatched area. From that section of the sample form, the following table represents the information the Administrative Officer aboard the USS ROAN provided on EM3 Tom Henry Jones:

	Item	As Recorded in Service Record
Final Mark	A School	77.86
	B "	(did not attend B School)
	C "	90
Class Standing	A "	57th
	B "	-
	C "	26th
Class Size	A "	122
	B "	-
	C "	27
Years of Civilian Education (Yrs. Ed.)		12
GCT Score		50
ARI "		49
MECH "		56
CLER "		47

If you have any questions regarding the type or the recording procedure of any of the desired information, please consult the liaison officer for this project. Once all PIIFs in all sets of Performance Evaluations Forms have been completed by you, return all packages to the liaison officer. Thank you for your cooperation and efforts in completing these forms.

SAMPLE PERSONNEL IDENTIFICATION INFORMATION FORM (PIIF)

NAME OF SUPERVISOR *Abner Smith* RATING/RATE *EMC*

DATE *7 January 72* SHIP OR UNIT *USS ROAN* LOCATION *Newport*

DIRECTIONS

Use a #2 pencil only. Blacken the answer rectangle completely. Cleanly erase answers you want to change. Erase any stray marks. 'TECHNICIAN' is the man being evaluated.

In the boxes just below, print as much as possible of the TECHNICIAN'S NAME. Start with his last name. print one letter to a box. Leave one box blank, then print his first name; leave another box blank, then his middle name, etc.

J	O	N	E	S		T	O	M		H	E
a–z	a–z	a–z	a–z	a–z	a–z	a–z	a–z	a–z	a–z	a–z	a–z

FINAL MARK

A School				B School				C School			
0–9	0–9	.0–.9	0–9	0–9	0–9	.0–.9	0–9	0–9	0–9	.0–.9	0–9

CLASS STANDING

0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9

CLASS SIZE

0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9

GCT		ARI		MECH		CLER		Yrs. Ed	
0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9

Technician's Birthdate

Month	19 *4*	*3*
Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec	0–9	0–9

Technician's Months

Known by Supervisor		on Current Job Assignment	
0–9	0–9	0–9	0–9

Technician's Months of Active Duty Service

USN		USNR	
0–9	0–9	0–9	0–9

Technician's

Rating	Paygrade
EM	E-1
ET	E-2
FT	E-3
IC	E-4
RD	E-5
RM	E-6
ST	E-7
TM	E-8
	E-9

Technician's Social Security No.

0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9

APPENDIX D

INSTRUCTIONS FOR SUPERVISOR

NOTE: The instructions on pages D-3 thru D-15 (pages -1 thru -13) of this report are paginated for publication. For economy of reproduction, the page numbers were not changed for this report.

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NAVAL PERSONNEL RESEARCH AND DEVELOPMENT LABORATORY
WASHINGTON, D.C.

Instructions for the Supervisor for Completing
Performance Evaluation Forms

You, as a supervisor, have been selected to participate in a performance evaluation program being conducted by the Naval Personnel Research and Development Laboratory. Performance evaluation in the U.S. Navy has served as a guideline for the optimal positioning of manpower and for feedback on Naval school effectiveness. It is felt that you will be the most qualified to give accurate and meaningful information on the performance of the men you supervise. For that reason it is necessary that you make an earnest effort at providing the information requested of you. Without your support and honest efforts, the time and funds put into this research endeavor will have been negated.

You are asked to complete a set of three performance evaluation forms for each petty officer and designated striker - in the EM, ET, FT, IC, RD, RM, ST, and TM ratings only - over whom you have immediate supervision. The titles and descriptions of the three experimental forms are:

1. Personnel Identification Information Form (PIIF) - this form is concerned with the background data of the man you are evaluating. You will complete part of it and the Administrative Officer aboard your ship will supply the remaining information.

2. Technical Proficiency Checkout Form (TPCF) - this form records the level of technical complexity at which a man is able to perform without direct supervision.

3. Job Performance Questionnaire (JPQ) ANSWER SHEET - this form records your estimates of the number of a man's uncommonly effective and ineffective performances that you have observed during a specified time period.

From your ship's liaison officer, who is coordinating this project, you have received a packet of materials containing these instructions and a number of blank copies of the three forms just described. Additional blank forms may also be obtained from the liaison officer if you need them. Together, these forms - the PIIF, TPCF, and JPQ ANSWER SHEET - constitute a full set of Performance Evaluation Forms. You are to fill out one of each type of form - one complete set of three forms - for each man whose performance you evaluate. You will have approximately one week in which to complete the sets of Performance Evaluation Forms for all the men who have been designated for you to evaluate. Please remember to use only a #2 pencil in filling out the Performance Evaluation Forms.

Turn now to pages 4, 6, and 13 of these instructions. On those pages are samples of the three Performance Evaluation Forms. Notice that each of the three sample forms is preceded by a page of instructions. These particular sample forms were completed for the following typical, naval situation.

> EMC Abner Smith is the immediate supervisor of seven men aboard the USS ROAN located at Newport. He had been given seven sets of Performance Evaluation Forms, with a Supervisor's Instruction Package, by the liaison officer aboard the USS ROAN. During the week of 7 January 1972, he completed all Performance Evaluation Forms. One of the men he evaluated was EM3 Tom Henry Jones. The samples on pages 4, 6, and 13 are therefore the PIIF, TPCF, and JPO ANSWER SHEET containing information on EM3 Tom Henry Jones furnished by his supervisor, EMC Abner Smith.

Before starting on the Performance Evaluation Forms, study the samples that are included in these instructions. Please do not let your answers be influenced by the information given on the sample Performance Evaluation Forms. The answers given on the sample forms are meant only to be guides in aiding you to complete your forms on the men you evaluate.

All responses to questions are completely CONFIDENTIAL. Any information you provide will be used only by the researchers of the Naval Personnel Research and Development Laboratory, and only to serve as a statistical data base for arriving at performance estimates of enlisted naval personnel in general.

Your help and cooperation in participating in this project are greatly appreciated by the project researchers at the Naval Personnel Research and Development Laboratory.

Instructions for Completing the PIIF

The Personnel Identification Information Form (PIIF) records various background information on the man you are evaluating. Refer to the sample PIIF on page 4 of these Instructions and the DIRECTIONS given there. Note that you need furnish only the information requested to the <u>right</u> of the cross-hatched area, namely:

a.	Technician's	<u>Name</u>
b.	"	<u>Social Security Number</u>
c.	"	<u>Birthdate</u>
d.	"	<u>Months Known by Supervisor</u>
e.	"	<u>Months on Current Job Assignment</u>
f.	"	<u>Months of Active Duty Service</u> (USN* and USNR**)
g.	"	<u>Rating and Paygrade</u>

It is understood that you will obtain most of this information directly from the man you are evaluating. It is important that this background information be as accurate as is possible. If you doubt the accuracy of any of the information you have obtained from the technician, or if you are unable to obtain it, please ask the Administrative Officer aboard your ship to provide you with the correct information. In addition, you as the supervisor will also fill out the two upper left lines of the PIIF. This includes your name, rating and rate, date, ship and its current homeport location.

From the sample PIIF on page 4, notice that the following information is obtained:

1. The supervisor is EMC Abner Smith located at Newport aboard the USS ROAN and completed this form on 7 January 1972.

2. This supervisor was evaluating EM3 Tom Henry Jones whose social security account number is 123-45-6789, and he was born in March, 1948. He was known for 13 months by the supervisor, and had been 15 months on his current job assignment. Jones had served no USNR active duty time but had been on USN active duty for 29 months.

---

*Record 99 months for USN if the Technician's Months of USN Active Duty Service equals or exceeds 99 months.

**Record 99 months for USNR active time if the Technician's Months of USNR Active Duty Service equals or exceeds 99 months.

SAMPLE PERSONNEL IDENTIFICATION INFORMATION FORM (PIIF)

NAME OF SUPERVISOR *Abner Smith* RATING/RATE *EMC*

DATE *7 January 72* SHIP OR UNIT *USS POAN* LOCATION *Newport*

THIS SECTION IS NOT

TO BE COMPLETED BY

THE SUPERVISOR

DIRECTIONS

Use a #2 pencil only. Blacken the answer rectangle completely. Cleanly erase answers you want to change. Erase any stray marks. 'TECHNICIAN' is the man being evaluated.

In the boxes just below, print as much as possible of the TECHNICIAN'S NAME. Start with his last name, print one letter to a box. Leave one box blank, then print his first name; leave another box blank, then his middle name, etc.

J	O	N	E	S		T	O	M		H	E
a	a	a	a	a	a	a	a	a	a	a	a
b	b	b	b	b	b	b	b	b	b	b	b
c	c	c	c	c	c	c	c	c	c	c	c
d	d	d	d	d	d	d	d	d	d	d	d
e	e	e	e	e	e	e	e	e	e	e	e
f	f	f	f	f	f	f	f	f	f	f	f
g	g	g	g	g	g	g	g	g	g	g	g
h	h	h	h	h	h	h	h	h	h	h	h
i	i	i	i	i	i	i	i	i	i	i	i
j	j	j	j	j	j	j	j	j	j	j	j
k	k	k	k	k	k	k	k	k	k	k	k
l	l	l	l	l	l	l	l	l	l	l	l
m	m	m	m	m	m	m	m	m	m	m	m
n	n	n	n	n	n	n	n	n	n	n	n
o	o	o	o	o	o	o	o	o	o	o	o
p	p	p	p	p	p	p	p	p	p	p	p
q	q	q	q	q	q	q	q	q	q	q	q
r	r	r	r	r	r	r	r	r	r	r	r
s	s	s	s	s	s	s	s	s	s	s	s
t	t	t	t	t	t	t	t	t	t	t	t
u	u	u	u	u	u	u	u	u	u	u	u
v	v	v	v	v	v	v	v	v	v	v	v
w	w	w	w	w	w	w	w	w	w	w	w
x	x	x	x	x	x	x	x	x	x	x	x
y	y	y	y	y	y	y	y	y	y	y	y
z	z	z	z	z	z	z	z	z	z	z	z

Technician's Birthdate

Month	19 *4*	*8*
Jan		
Feb		
Mar	0	0
Apr	1	1
May	2	2
Jun	3	3
Jul	4	4
Aug	5	5
Sep	6	6
Oct	7	7
Nov	8	8
Dec	9	9

Technician's Months

Known by Supervisor		on Current Job Assignment	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

Technician's Months of Active Duty Service

USN		USNR	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

Technician's

Rating	Paygrade
EM	E-1
ET	E-2
FT	E-3
IC	E-4
RD	E-5
RM	E-6
ST	E-7
TM	E-8
	E-9

Technician's Social Security No.

0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9

Instructions for Completing the TPCF

A sample of a completed Technical Proficiency Checkout Form is shown on page 6, completed by EMC Abner Smith for EM3 Tom Henry Jones. Eight tasks are listed in descending order of difficulty. It is felt that an individual's overall proficiency is directly related to the highest level of task in the set which he can perform without direct supervision.

Beginning with task description NO. 1. (Capable of employing safety precautions ...), place an "X" in the "CHECKED OUT" box if you feel that the man you are evaluating is capable of performing the task on his own without direct supervision. If you feel he is not able to perform the task on his own, place an "X" in the "NOT CHECKED OUT" box. Complete this form by going through the eight tasks described. Be sure to provide the information at the top of the TPCF form, to include your name, rating and rate, full name of the man evaluated, ship and its current homeport location, and the date. Refer to the sample TPCF given on page 6 of these instructions. You will notice that EMC Abner Smith marked EM3 Tom Henry Jones, as being "CHECKED OUT" on tasks 1 through 6, but felt that he was not able to perform tasks 7 and 8 without direct supervision.

SAMPLE

TECHNICAL PROFICIENCY CHECKOUT FORM

NAME OF SUPERVISOR *Abner Smith* RATING/RATE *EMC*

FULL NAME OF MAN EVALUATED *Tom Henry Jones*

SHIP OR UNIT *USS ROAN* LOCATION *Newport* DATE *7 January 72*

TASK DESCRIPTION	CHECKED OUT	NOT CHECKED OUT
1. Capable of <u>employing safety precautions</u> on most of this unit's equipment with which his rating is concerned.	☒	☐
2. Capable of <u>replacing</u> most of this unit's equipment with which his rating is concerned.	☒	☐
3. Capable of <u>removing</u> most of this unit's equipment with which his rating is concerned.	☒	☐
4. Capable of <u>following block diagrams</u> for most of this unit's equipment with which his rating is concerned.	☒	☐
5. Capable of <u>knowing relationship of equipment to other related</u> equipment with which his rating is concerned.	☒	☐
6. Capable of <u>calibrating</u> most of this unit's equipment with which his rating is concerned.	☒	☐
7. Capable of <u>trouble-shooting/isolated malfunction(s)</u> in most of this unit's equipment with which his rating is concerned.	☐	☒
8. Capable of <u>employing electronic principles involved in maintenance</u> of most of this unit's equipment with which his rating is concerned.	☐	☒

MAKE CERTAIN THERE IS AN "X" IN A BOX OPPOSITE EACH TASK DESCRIPTION

Instructions for Completing the JPQ ANSWER SHEET

The purpose of the Job Performance Questionnaire (JPQ) ANSWER SHEET is to record, for a given individual, your estimates of the total number of uncommonly effective and uncommonly ineffective incidents of performance you have observed during the last two months on each of eight job activities (see page 8).

In previous efforts at evaluating the performance of an individual, such as the reports of Enlisted Performance Evaluation, you mentally "averaged" your observations of excellent and poor incidents of performance for that man in order to arrive at an overall performance estimate. However, in this project we are asking you to focus your attention on only the extremes of performance -- uncommonly effective and uncommonly ineffective performances. In addition, we want you to disregard an individual's overall performance and to record for each of the eight job activities the total number of times you have observed the occurrence of uncommonly effective and uncommonly ineffective incidents of performance.

As a general example, on a particular day a man has demonstrated two incidents of uncommonly effective performance while involved in the job activity Equipment Operation and no incident of uncommonly ineffective behavior for that job activity on that day. Sometime later, on perhaps another day, he has demonstrated one uncommonly effective performance and one uncommonly ineffective performance for the job activity Equipment Operation. If in the past two months no other of his duties involved Equipment Operation, then your estimate of the total number of uncommonly effective and uncommonly ineffective incidents of performance, for that job activity, is three uncommonly effective and one uncommonly ineffective incident of performance.

In order to determine exactly what specific types of activities you should consider in estimating whether the man has shown an "uncommonly effective" or an "uncommonly ineffective" performance, refer to the DESCRIPTION of that JOB ACTIVITY as given in the following list:

DESCRIPTION OF JOB ACTIVITIES

JOB ACTIVITY	DESCRIPTION

1. Using Reference Materials--includes the following type of activities:

   a. use of supporting reference materials
   b. making out reports

2. Equipment Operation--includes the following type of activity:

   a. operating equipment, electrical and electronics test equipment, and other electronic equipments

3. Electronic Circuit Analysis--includes the following type of activities:

   a. understanding the principles of electronic circuitry
   b. making out failure reports
   c. keeping records of maintenance usage data

4. Personnel Relationships--includes the following type of activity:

   a. supervising the operation, inspection, and maintenance of electronic equipments

5. Electro-safety--includes the following type of activity:

   a. using safety precautions on self and equipment

6. Instruction--includes the following type of activity:

   a. teaching others how to inspect, operate, and maintain electronic equipments

7. Electro-repair--includes the following type of activity:

   a. equipment repair in the shop

8. Electro-cognition--includes the following type of activities:

   a. maintenance and troubleshooting of electronic equipments
   b. use of electronic maintenance reference materials

Because you are the most knowledgeable of the area you supervise, you will know what incidents of performance can be labeled as uncommonly effective or uncommonly ineffective. It is your standard that is to be used for this trial. However, to further assist you the researchers have provided the following general definitions.

An uncommonly effective performance in a specific job activity is an impressive and/or decisive incident of performance qualitatively above those usually observed. Likewise, an uncommonly ineffective performance in a specific job activity is an impressive and/or decisive incident of performance qualitatively below those usually observed.

With this in mind, turn to the sample of a JPQ ANSWER SHEET on page 13. Under each JOB ACTIVITY are three columns - (a), (b), and (c). Notice that under "Using Reference Materials", column (a), the estimate of the total number of uncommonly effective (UE) performances observed during the past two months for EM3 Tom Henry Jones was two. That is, the supervisor, EMC Abner Smith, estimated that altogether he observed two impressive incidents of performance for EM3 Tom Henry Jones which were qualitatively above those usually observed. Similarly for column (b), the supervisor's estimate of the total number of uncommonly ineffective (UI) performance is one. Disregard part (c) for the moment.

The estimates recorded on the JPQ ANSWER SHEET will be machine processed and must be accurately recorded. The sample on page 13 together with the following table, illustrates the correct procedure for recording one-digit numbers (numbers 0 through 9), and for recording two-digit numbers (numbers 10 through 99), in various positions on the JPQ ANSWER SHEET. Review the table in conjunction with the page 13 sample.

JOB ACTIVITY	No. of UE	No. of UI
Using Reference Materials	2	1
Equipment Operation	10	5
Electronic Circuit Analysis	14	12
Personnel Relationships	0	0
Electro-safety	0	2
Instruction		
Electro-repair	2	1
Electro-cognition	1	1

NOTE: If the man has not had an opportunity to perform a particular activity, leave that job activity unmarked (as shown for "Instruction" on the sample JPQ ANSWER SHEET).

If he has had an opportunity to perform a particular activity, but has not shown any uncommonly effective or ineffective performances, enter a zero (0) for both UE and UI (as shown for "Personnel Relationships" on the sample JPQ ANSWER SHEET).

While observing a technician perform any of the eight JOB ACTIVITIES, you, as his supervisor, may have had many objectives in mind which you felt he should be striving for. However, for the purposes of this trial, we ask you to limit your attention to only the following fleet electronic maintenance objectives:

MEANINGS OF FLEET ELECTRONICS MAINTENANCE OBJECTIVES

1. Readiness

To maintain efficiently self, subordinate personnel, equipment, and systems in state of readiness consistent with fleet requirements.

2. Performance

To complete any given mission in minimum time with appropriate level of accuracy and reliability.

3. Operation

To obtain optimum system output when equipment is operated, i.e., output characterized by precision and variability appropriate to mission.

4. Safety

To carry out duties with maximum protection for men and equipment consistent with mission.

5. Preparation

To prepare for personnel requirements of present and future equipment, systems, and situations through use of training programs, maintenance of high morale, etc.

* * * * *

After recording the estimates of the number of UE and UI performances for each of the eight JOB ACTIVITIES, complete the JPQ ANSWER SHEET by placing, in column (c) for each job activity, your reply to the following question:

QUESTION (c) Considering this man's overall performance, it is your opinion that the importance of this job activity, as a factor in determining the overall performance of this man, is best described as being:

3. of central and primary importance
2. a significant factor, but of secondary importance
1. of only moderate importance in estimating overall performance
0. of little or no importance

On the sample JPQ ANSWER SHEET on page 13, QUESTION (c) was answered as 2, 3, 3, 2, 1, 0, 2, 3, respectively for each of the eight JOB ACTIVITIES. For this particular man, his supervisor felt that the job activity, "Equipment Operation," was of primary importance as a factor in determining the man's overall job performance.

* * * * *

Answer the following questions in the block marked QUESTIONS in the lower corner provided on the JPQ ANSWER SHEET.

QUESTION (d) You were asked to recall the number of UE and UI performances that you have observed for this man during the past two months. You feel that a reasonable time span for evaluation would be:

1. two months
2. six weeks
3. four weeks
4. two weeks
5. one week

QUESTION (e) What degree of confidence have you that your estimated number of UE and UI performances for this man are very close to the actual number of such performances that occurred during this time period?

1. My estimates are probably very close to the actual numbers.
2. There may have been a few UE or UI performances more or less than my estimates.
3. Cannot be too sure about my estimates. It was very difficult to recall UE and UI performances.
4. The actual number of UE and UI performances could be very different from my estimates. Recalling these UE and UI incidents is too difficult to have any confidence in such estimates.

QUESTION (f) Aside from his performance, to what extent are this man's efforts on the job devoted to tasks and activities directly related to his rating? Compare this amount of rating-related activity to the average for men in his rating and paygrade.

1. Involved in definitely more rating-related activities than is usual in his rating and paygrade.
2. Involved in about the same rating-related activities as usual in his rating and paygrade.
3. Involved in less rating-related activities than is usual in his rating and paygrade.

The above questions were answered as 2, 1, and 3 respectively on the sample of the JPQ ANSWER SHEET of page 13 of these Instructions.

* * * * *

Finally, place your social security account number in the block provided. Also be sure to record your name, rating and rate, ship and its current homeport location, date, and the name of the man you are evaluating at the top of the JPQ ANSWER SHEET.

NAME OF MAN EVALUATED *Tom Henry Jones*

NAME OF SUPERVISOR *Abner Smith* RATING/RATE *EMC*

DATE *7 January 72* SHIP OR UNIT *USS ROAN* LOCATION *Newport*

SAMPLE JPQ ANSWER SHEET

Using Reference Materials					Equipment Operation					Electronic Circuit Analysis					Personnel Relationships				
(a) UE		(b) UI		(c)	(a) UE		(b) UI		(c)	(a) UE		(b) UI		(c)	(a) UE		(b) UI		(c)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4		4	4	4	4		4	4	4	4		4	4	4	4	
5	5	5	5		5	5	5	5		5	5	5	5		5	5	5	5	
6	6	6	6		6	6	6	6		6	6	6	6		6	6	6	6	
7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7	
8	8	8	8		8	8	8	8		8	8	8	8		8	8	8	8	
9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9	

Electro-safety					Instruction					Electro-repair					Electro-cognition				
(a) UE		(b) UI		(c)	(a) UE		(b) UI		(c)	(a) UE		(b) UI		(c)	(a) UE		(b) UI		(c)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4		4	4	4	4		4	4	4	4		4	4	4	4	
5	5	5	5		5	5	5	5		5	5	5	5		5	5	5	5	
6	6	6	6		6	6	6	6		6	6	6	6		6	6	6	6	
7	7	7	7		7	7	7	7		7	7	7	7		7	7	7	7	
8	8	8	8		8	8	8	8		8	8	8	8		8	8	8	8	
9	9	9	9		9	9	9	9		9	9	9	9		9	9	9	9	

QUESTIONS		
(d)	(e)	(f)
1	1	1
2	2	2
3	3	3
4	4	
5		

Supervisor's Social Security No.								
0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9

FOR OFFICE USE ONLY

Sq.	Ship	Ind. No.	TPC
	0	0	
	1	1	
	2	2	
	3	3	
	4	4	
	5	5	
	6	6	
	7	7	
	8	8	
	9	9	

GPO 923-849

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APPENDIX E

PROBLEMS IN CALCULATING RELIABILITY RATIOS

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PROBLEMS IN CALCULATING RELIABILITY RATIOS

The purpose of this section is to examine the frequency with which the two cases:

1. a technician did not work at a job activity, and

2. a technician received $\Sigma UE = 0$ and $\Sigma UI = 0$,

occurred for each rating and job activity across all 21 ships participating in the project. From this one can infer on the extent which any convention for estimating performance in those cases would affect individual SRE, PRE, and GRE values.

Refer to Table E-1 on page E-4. Each square in the table represents the number and proportion of technicians by rating who did not work at a particular job activity or received $\Sigma UE = 0$ and $\Sigma UI = 0$ by their supervisor. Therefore, on job activity Number 1, 25 of the EM's (or 25.8% of the EM's) evaluated either do not work at that job activity (Using Reference Materials) or received $\Sigma UE = 0$ and $\Sigma UI = 0$. This may seem a tolerable level of occurrence of such cases, but when the proportion of such cases exceeds .33, one should begin to consider whether the performance of some individuals is due more to the convention that must be adopted rather than to the individual's own job effectiveness. Of the 64 squares in the table, 42 squares had one-third or more of the men in some rating falling into the two cases for some job activity, 25 squares had one-half or more of the men in some rating falling into the two cases, and most critically, 6 squares had at least 75% of the men in those cases. The RD and RM ratings were particularly notorious for this type of situation occurring. No rating seems to be entirely free of this situation for some job activities. However, some ratings significantly demonstrate this effect for many job activities.

TABLE E-1

NUMBER AND PROPORTION OF TECHNICIANS IN PROBLEM AREAS

Job Activity	Rating: EM	ET	FT	IC	RD	RM	ST	TM
1	25 0,258	38 0,220	56 0,364	9 0,155	50 0,360	53 0,387	45 0,296	6 0,154
2	23 0,237	47 0,272	49 0,318	7 0,121	53 0,381	42 0,307	45 0,296	13 0,333
3	42 0,433	45 0,260	75 0,487	18 0,310	133 0,957	104 0,759	69 0,454	26 0,667
4	43 0,443	83 0,480	93 0,604	27 0,466	75 0,540	77 0,562	76 0,500	10 0,256
5	23 0,237	83 0,480	80 0,519	7 0,121	76 0,547	50 0,365	62 0,408	11 0,282
6	50 0,515	116 0,671	115 0,747	35 0,603	100 0,719	88 0,642	90 0,592	20 0,513
7	18 0,186	48 0,277	83 0,539	5 0,086	137 0,993	128 0,934	76 0,500	25 0,641
8	35 0,361	48 0,277	64 0,416	12 0,207	132 0,950	114 0,832	61 0,401	22 0,564
Number of Men Each Rating	97	173	154	58	139	137	152	39

APPENDIX F

THE ADOPTION OF A CONVENTION FOR EACH JOB ACTIVITY AND RATING

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THE ADOPTION OF A CONVENTION FOR EACH JOB ACTIVITY AND RATING

This section discusses the finding that no convention can be adopted per ship that will account for those cases in which a technician either does not work at a particular job activity or received $\Sigma UE = 0$ and $\Sigma UI = 0$ from his supervisor. As an example, observe Table F-1. This table is of the same type as that previously reported on for all 949 men participating in the project (Appendix E, Table E-1). However, Table F-1 is reporting on only one typical ship out of 21 ships in the project. For this ship there were 8 (out of 64) instances where one of those two cases occurred for all men in some job activity and rating. The other ten ships at Location No. 1 demonstrated 16, 7, 8, 10, 13, 12, 5, 5, 5, and 16 (out of 64) instances. The 10 ships at Location No. 2 demonstrated 1, 16, 5, 15, 7, 8, 16, 14, 10, and 15 (out of 64) such instances. Therefore, it is impossible to form an average estimate (or some composite value) per ship for each rating and job activity because, in some ratings and job activities on all ships, there are no technicians who received either ΣUE or ΣUI different from zero.

Derivation of Composite Reliability Values

In order to overcome the aforementioned problem, the convention employed in the report was to develop a composite reliability score to estimate technician performance on those job activities in which the technician received $\Sigma UE = \Sigma UI = 0$ or did not work at that particular job activity.

Let $\Sigma UE(i,j)$ be the sum across all ships at a location of all ΣUE's over all men in the i^{th} rating and j^{th} job activity. Similarily the sum of all ΣUI's is calculated; denote this sum by $\Sigma UI(i,j)$. The composite reliability score for the i^{th} rating and j^{th} job activity is defined as:

$$R(i,j) = \Sigma UE(i,j)/[\Sigma UE(i,j) + \Sigma UI(i,j)].$$

This particular estimate of job performance provides an "expected" level of effectiveness for a technician in the i^{th} rating and j^{th} job activity (for ships at a particular location). Table F-2 gives the resulting composite reliability values ($R(i,j)$) for each rating and job activity at each location. For example, from Table F-2 and men at Location No. 1 (Cruiser-Destroyer Flottilla NINE), $R(1,3)$ is the composite reliability value for EM's on job activity number 3 - Electronic Circuit Analysis - and is given by $R(1,3) = .8465$. Reiterating, it may be said that for all EM's at Location No. 1 who have not worked at job activity number 3 or who received $\Sigma UE = 0$ and $\Sigma UI = 0$ for that job activity, their reliability ratio for that job activity is expected to be $r_3 = R(1,3) = .8465$. Similarly this procedure is employed on the other ratings and job activities.

The composite reliability score is an estimate that always can be derived when many ships are involved. However, it does not overcome the implications of the results discussed in Appendix E and their subsequent effect on the estimates SRE, PRE, and GRE.

TABLE F-1

NUMBER AND PROPORTION OF TECHNICIANS IN PROBLEM AREAS ON A PARTICULAR SHIP

Job Act.	Rating: EM	ET	FT	IC	RD	RM	ST	TM
1	4 0.667	9 0.310	5 0.417	0 0.0	0 0.0	9 0.900	0 0.0	0 0.0
2	6 [illegible]	13 0.448	7 0.583	0 0.0	0 0.0	9 0.900	0 0.0	1 0.077
3	5 0.833	14 0.483	7 0.583	1 0.167	0 0.0	10 1.000	0 0.0	9 0.692
4	6 [illegible]	18 0.621	10 0.833	3 0.500	0 0.0	9 0.900	0 0.0	5 0.385
5	6 [illegible]	21 0.724	8 0.667	0 0.0	0 0.0	6 0.600	0 0.0	1 0.077
6	5 0.833	21 0.724	9 0.750	0 0.0	0 0.0	10 1.000	0 0.0	5 0.385
7	5 0.833	11 0.379	12 1.000	1 0.167	0 0.0	9 0.900	0 0.0	9 0.692
8	6 1.000	16 0.552	8 0.667	1 0.167	0 0.0	10 1.000	0 0.0	6 0.462
Number of Men Each Rating	6	29	12	6	0	10	0	13

TABLE F-2

COMPOSITE RELIABILITY VALUES

Location No. 1

Job Activity	Rating EM	ET	FT	IC	RD	RM	ST	TM
1	0.8770	0.6831	0.7160	0.7466	0.9257	0.9310	0.8537	0.7333
2	0.9050	0.7733	0.7802	0.8217	0.9110	0.9497	0.8899	0.8165
3	0.8465	0.6932	0.7340	0.7981	0.9000	1.0000	0.8662	0.8667
4	0.8639	0.5987	0.7890	0.7692	0.9300	0.9671	0.8930	0.7733
5	0.9004	0.7706	0.9107	0.7865	0.9012	0.9712	0.916[illegible]	0.7284
6	0.9333	0.8481	0.8435	0.8039	0.9677	0.9877	0.8571	0.8974
7	0.8981	0.7872	0.8701	0.8163	1.0000	1.0000	0.9078	0.8269
8	0.8744	0.7097	0.7771	0.8105	1.0000	0.9949	0.8571	0.7419

Location No. 2

Job Activity	Rating EM	ET	FT	IC	RD	RM	ST	TM
1	0.9101	0.7203	0.8552	0.7879	0.8352	0.8351	0.8547	0.5806
2	0.8962	0.7110	0.8808	0.8673	0.9017	0.8673	0.8567	0.8095
3	0.8342	0.7803	0.8673	0.7719	1.0000	0.8402	0.8[illegible]94	0.0909
4	0.9586	0.6729	0.8167	0.9333	0.8214	0.8240	0.7950	0.7317
5	0.8987	0.8244	0.9032	0.9718	0.8649	0.9667	0.9135	0.6000
6	0.9530	0.7368	0.9231	0.8095	0.7975	1.0000	0.6759	0.8333
7	0.9441	0.7866	0.8819	0.8240	0.0000	1.0000	0.8148	0.5714
8	0.9120	0.7918	0.8827	0.8267	0.7059	1.0000	0.8357	0.4167

APPENDIX G

A FEW REMARKS ON CURVILINEAR REGRESSION

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A FEW REMARKS ON CURVILINEAR REGRESSION

Let Y be a criterion variable and let X be a predictor variable. If N is the number of observations on each of X and Y, then $Y' = [Y_1, \ldots, Y_N]$ is the row vector of N observations on Y. For a given matrix A, A' will be the transpose of A. In particular one wishes to establish a regression equation for a particular response Y in terms of the variables X, X^2, X^3; i.e. it is desirable to establish which of the three power curves (linear, quadratic, or cubic):

$$Y = \beta_0 + \sum_{i=1}^{p} \beta_i X^i \qquad p = 1, 2, \underline{\text{or}}\ 3$$

best fits the observations obtained on X and Y. The above equations, in terms of the sample observation vectors, can be expressed in matrix notation as:

$$Y = X\beta + E$$

where Y was defined above. The matrix $X_i = [J, X_1, X_2, X_3]$ where $J' = [1, \ldots, 1]_{1xN}$ and $X_i' = [X_1^i, \ldots, X_N^i]$ for i = 1, 2, or 3. Therefore X_1 is an N x 1 column vector of observations on the predictor variable. $\beta' = [\beta_0, \ldots, \beta_p]$ is the vector of p + 1 regression parameters. $E'=[e_1,\ldots,e_N]$ is the vector of errors due to lack of fit in the particular model. One wishes to estimate β such that the error sum of squares is minimized. In particular a <u>least squares estimate</u> $\tilde{\beta}$ of β is given by

$$\tilde{\beta} = (X'X)^{-1}X'Y$$

provided the square matrix $X'X$ is nonsingular and the regression problem has been properly expressed. The usual assumption one makes is that E' is distributed with mean $[0, \ldots, 0]_{1xN}$ and variance-covariance matrix $\sigma^2 I$ where I is the identity matrix. The term σ^2 is called the common error variance of the observations. The assumption of normality of the error vector is not required in order to obtain the least squares estimates for any of the parameters in the regression equation. Because any assumption of normality for E implies that the observations on X or Y are normally distributed, this report will only be concerned with least squares estimates. One cannot in general discuss normality on X or Y because of some results in this report where it is shown that the distribution of TP scores, SRE, PRE, and GRE are not normally distributed (see Table 17 and page 21). Therefore it is imperative that the reader be aware that while the assumption of E being normally distributed is not required in order to obtain $\tilde{\beta}$, it is required in order to make tests of hypotheses, as contained in an Analysis of Variance Table. These tests are the usual t- or F-tests and they cannot be applied validly to the sample data collected at either location nor on the combined sample consisting of 949 technicians for the variables SRE, PRE, GRE, and TP score (see, for example, Draper and Smith [7], page 59).

A Least Squares Analysis of the Sample Data

It is possible that a least squares analysis can be attempted independently of the distributional properties of the criterion and predictor variables. For a particular predictor variable (X) and criterion variable (Y), the multiple correlation coefficient (R^2) provides a measure of the proportion of the total variance about the sample mean for the criterion variable explained by a particular regression model. The term R^2 is defined as:

$$R^2 = \frac{\text{Sum of squares due to regression} - \text{Sum of squares due to } \beta_0}{\text{Total (corrected) sum of squares}}$$

$$= (\hat{\beta}X'Y - \frac{Y'Y}{N}) / (Y'Y - \frac{Y'Y}{N})$$

It should be clear that the larger R^2 is, the better the fitted equation explains variance in the criterion variable. Furthermore, $0 \leq R^2 \leq 1$, and therefore $R^2 = 1$ implies a perfect fit. However there are a few problems with this approach (see, for example Draper and Smith [7], page 63). One must weigh the value of R^2 with the least squares estimate (s^2) of the common error variance (σ^2) where

$$s^2 = \text{residual mean square}$$

$$= (Y'Y - \frac{Y'Y}{N}) / (N - p - 1).$$

Of course, the smaller s^2 is for a particular model under consideration the better the model fits the data. Therefore the approach is to weigh increases in R^2 with decreases in s^2 in order to arrive at the best least squares model for the data.

APPENDIX H

RESULTS OF THE CURVILINEAR
REGRESSION ON 949 TECHNICIANS EVALUATED

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POLYNOMIAL FITTING FOR    2 VARIABLES-SRE AND TP SCORE.   949 OBSERVATIONS.


THE PREDICTOR VARIABLE(X) IS SRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.


TEST MEANS AND STANDARD DEVIATIONS
 1       X            0.331       0.323
 2   SQUAR            0.214       0.288
 3   X CUBE           0.15?       0.265
 4       Y            5.35?       ?.340
CORRELATION MATRIX
 1       X            1.000       0.953       0.887       0.055
 2   SQUAR            0.953       1.000       0.983       0.032
 3   X CUBE           0.887       0.983       1.000       0.034
 4       Y            0.055       0.032       0.034       1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS,
MULTIPLE R SQUARE =     0.003
MULTIPLE R =     0.055
N.D.F.1 =    1
N.D.F.2 =          947
F FOR ANALYSIS OF VARIANCE ON R =       2.850
BETA WEIGHTS
  0.055
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X          0.003       1.000
SQUARED BETA WEIGHTS
  0.003
B WEIGHTS
  0.397
INTERCEPT CONSTANT =       5.219
MULTIPLE R SQUARE =     0.007
MULTIPLE R =     0.086
N.D.F.1 =    2
N.D.F.2 =          946
F FOR ANALYSIS OF VARIANCE ON R =       3.537
BETA WEIGHTS
  0.264   -0.220
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X          0.014       0.636
   2   SQUAR         -0.007       0.372
SQUARED BETA WEIGHTS
  0.070   0.048
B WEIGHTS
  1.912   -1.783
INTERCEPT CONSTANT =       5.098
MULTIPLE R SQUARE =     0.043
MULTIPLE R =     0.207
N.D.F.1 =    3
N.D.F.2 =          945
F FOR ANALYSIS OF VARIANCE ON R =     14.091
BETA WEIGHTS
 -1.492   -3.627    2.276
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X          0.082       0.265
   2   SQUAR         -0.116       0.155
   3   X CUBE         0.077       0.164
SQUARED BETA WEIGHTS
  2.226   13.157    5.179
B WEIGHTS
 13.803  -29.457   20.101
INTERCEPT CONSTANT =       4.869



ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.003
 RESIDUAL S.S. =         0.997   DF =      947   RESIDUAL M.S. =          0.001
F FOR LINEAR FIT =      2.850

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =          0.007
REDUCTION M.S. =         0.004
 RESIDUAL S.S. =         0.993   DF =      946   RESIDUAL M.S. =          0.001
F FOR QUADRATIC FIT =      3.537
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.004
F FOR QUADRATIC TERM ALONE =      4.215

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =          0.043
REDUCTION M.S. =         0.014
 RESIDUAL S.S. =         0.957   DF =      945   RESIDUAL M.S. =          0.001

F FOR GENERAL CUBIC FIT =     14.091
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =          0.035
F FOR CUBIC TERM ALONE =     34.943
```

```
===========================================================================
POLYNOMIAL FITTING FOR    2 VARIABLES-PRE AND TP SCORE,   949 OBSERVATIONS.


THE PREDICTOR VARIABLE(X) IS PRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.


TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.558       0.467
 2   SQUAR         0.477       0.388
 3   X CUBE        0.420       0.377
 4      Y          5.350       2.340
CORRELATION MATRIX
 1      X          1.000       0.976       0.934       0.100
 2   SQUAR         0.976       1.000       0.989       0.063
 3   X CUBE        0.934       0.989       1.000       0.036
 4      Y          0.100       0.063       0.036       1.000
===========================================================================
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
===========================================================================
MULTIPLE R SQUARE =     0.010
MULTIPLE R =     0.100
N.D.F.1 =    1
N.D.F.2 =        947
F FOR ANALYSIS OF VARIANCE ON R =       9.576
BETA WEIGHTS
  0.100
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        0.010       1.000
SQUARED BETA WEIGHTS
  0.010
B WEIGHTS
  0.576
INTERCEPT CONSTANT =       5.028
===========================================================================
MULTIPLE R SQUARE =     0.036
MULTIPLE R =     0.189
N.D.F.1 =    2
N.D.F.2 =        946
F FOR ANALYSIS OF VARIANCE ON R =      17.508
BETA WEIGHTS
  0.817  -0.734
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        0.082       0.530
   2   SQUAR      -0.046       0.332
SQUARED BETA WEIGHTS
  0.667   0.539
B WEIGHTS
  4.700  -4.431
INTERCEPT CONSTANT =       4.838
===========================================================================
MULTIPLE R SQUARE =     0.036
MULTIPLE R =     0.189
N.D.F.1 =    3
N.D.F.2 =        945
F FOR ANALYSIS OF VARIANCE ON R =      11.665
BETA WEIGHTS
  0.754  -0.579  -0.095
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        0.075       0.529
   2   SQUAR      -0.036       0.332
   3   X CUBE     -0.003       0.192
SQUARED BETA WEIGHTS
  0.569   0.335   0.009
B WEIGHTS
  4.341  -3.495  -0.590
INTERCEPT CONSTANT =       4.841


ANOVA TABLE FOR POLYNOMIALS
===========================================================================
REDUCTION DUE TO LINEAR FIT, WITH 1 DF =       0.010
RESIDUAL S.S. =        0.990  DF =     947  RESIDUAL M.S. =       0.001
F FOR LINEAR FIT =     9.576
===========================================================================

REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =       0.036
REDUCTION M.S. =       0.018
RESIDUAL S.S. =        0.964  DF =     946  RESIDUAL M.S. =       0.001
F FOR QUADRATIC FIT =     17.508
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =       0.026
F FOR QUADRATIC TERM ALONE =    25.195
===========================================================================

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =       0.036
REDUCTION M.S. =       0.012
RESIDUAL S.S. =        0.964  DF =     945  RESIDUAL M.S. =       0.001
 OR GENERAL CUBIC FIT =   11.665
UCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,      0.000
 OR CUBIC TERM ALONE =    0.018
===========================================================================
```

```
POLYNOMIAL FITTING FOR    2 VARIABLES-GRE AND TP SCORE,   949 OBSERVATIONS.

THE PREDICTOR VARIABLE(X) IS GRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1       X           0.927        0.145
 2    SQUAR          0.879        0.177
 3    X CUBE         0.839        0.210
 4       Y           5.350        2.340
CORRELATION MATRIX
 1       X           1.000        0.956        0.895        0.087
 2    SQUAR          0.956        1.000        0.986        0.081
 3    X CUBE         0.895        0.986        1.000        0.077
 4       Y           0.087        0.081        0.077        1.000
================================================================================
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
================================================================================
MULTIPLE R SQUARE =     0.008
MULTIPLE R =     0.087
N.D.F.1 =    1
N.D.F.2 =         947
F FOR ANALYSIS OF VARIANCE ON R =       7.161
BETA WEIGHTS
  0.087
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
  1      X          0.008        1.000
SQUARED BETA WEIGHTS
  0.008
B WEIGHTS
  1.400
INTERCEPT CONSTANT =      4.053
================================================================================
MULTIPLE R SQUARE =     0.008
MULTIPLE R =     0.087
N.D.F.1 =    2
N.D.F.2 =         946
F FOR ANALYSIS OF VARIANCE ON R =       3.589
BETA WEIGHTS
  0.103  -0.017
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
  1      X          0.009        0.998
  2    SQUAR       -0.001        0.937
SQUARED BETA WEIGHTS
  0.011   0.000
B WEIGHTS
  1.663  -0.225
INTERCEPT CONSTANT =      4.006
================================================================================
MULTIPLE R SQUARE =     0.009
MULTIPLE R =     0.094
N.D.F.1 =    3
N.D.F.2 =         945
F FOR ANALYSIS OF VARIANCE ON R =       2.798
BETA WEIGHTS
  0.661  -1.542   1.005
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
  1      X          0.057        0.923
  2    SQUAR       -0.125        0.867
  3    X CUBE       0.077        0.816
SQUARED BETA WEIGHTS
  0.438   2.378   1.010
B WEIGHTS
 10.690 -20.332  11.213
INTERCEPT CONSTANT =      3.914


ANOVA TABLE FOR POLYNOMIALS
================================================================================
REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.008
RESIDUAL S.S. =       0.992  DF =      947  RESIDUAL M.S. =       0.001
F FOR LINEAR FIT =     7.161
================================================================================

REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.008
REDUCTION M.S. =       0.004
RESIDUAL S.S. =        0.992  DF =      946  RESIDUAL M.S. =       0.001
F FOR QUADRATIC FIT =      3.589
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =       0.000
F FOR QUADRATIC TERM ALONE =     0.024
================================================================================

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =       0.009
REDUCTION M.S. =       0.003
RESIDUAL S.S. =        0.991  DF =      945  RESIDUAL M.S. =       0.001

F FOR GENERAL CUBIC FIT =      2.798
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,      0.001
F FOR CUBIC TERM ALONE =     1.215
================================================================================
```

```
POLYNOMIAL FITTING FOR    2-VARIABLES-WRE AND TP SCORE.   949 OBSERVATIONS,

THE PREDICTOR VARIABLE(X) IS WRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1        X          0.603        0.204
 2     SQUAR         0.405        0.231
 3    X CUBE         0.290        0.227
 4        Y          5.350        2.340
CORRELATION MATRIX
 1        X          1.000        0.970       0.920       0.257
 2     SQUAR         0.970        1.000       0.986       0.247
 3    X CUBE         0.920        0.986       1.000       0.229
 4        Y          0.257        0.247       0.229       1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.066
MULTIPLE R =     0.257
N.D.F.1 =    1
N.D.F.2 =          947
F FOR ANALYSIS OF VARIANCE ON R =      67.017
BETA WEIGHTS
  0.257
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, (2ND COLUMN)
   1      X          0.066        1.000
SQUARED BETA WEIGHTS
  0.066
B WEIGHTS
  2.950
INTERCEPT CONSTANT =      3.571
MULTIPLE R SQUARE =     0.066
MULTIPLE R =     0.257
N.D.F.1 =    2
N.D.F.2 =          946
F FOR ANALYSIS OF VARIANCE ON R =      33.519
BETA WEIGHTS
  0.294  -0.038
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, (2ND COLUMN)
   1      X          0.076        0.999
   2    SQUAR       -0.009        0.961
SQUARED BETA WEIGHTS
  0.086   0.001
B WEIGHTS
  3.371  -0.384
INTERCEPT CONSTANT =      3.473
MULTIPLE R SQUARE =     0.071
MULTIPLE R =     0.266
N.D.F.1 =    3
N.D.F.2 =          945
F FOR ANALYSIS OF VARIANCE ON R =      23.999
BETA WEIGHTS
 -0.337    1.572  -1.012
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, (2ND COLUMN)
   1      X         -0.087        0.965
   2    SQUAR        0.389        0.929
   3   X CUBE       -0.231        0.859
SQUARED BETA WEIGHTS
  0.113    2.472   1.024
B WEIGHTS
 -3.865   15.953 -10.453
INTERCEPT CONSTANT =      4.246


ANOVA TABLE FOR POLYNOMIALS
REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.066
RESIDUAL S.S. =        0.934   DF =      947   RESIDUAL M.S. =        0.001
F FOR LINEAR FIT =    67.017

REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.066
REDUCTION M.S. =        0.033
RESIDUAL S.S. =         0.934   DF =      946   RESIDUAL M.S. =        0.001
F FOR QUADRATIC FIT =    33.519
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.000
F FOR QUADRATIC TERM ALONE =     0.085

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.071
REDUCTION M.S. =        0.024
RESIDUAL S.S. =         0.929   DF =      945   RESIDUAL M.S. =        0.001
F FOR GENERAL CUBIC FIT =    23.999
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,        0.005
F FOR CUBIC TERM ALONE =     4.698
```

APPENDIX I

RESULTS OF THE CURVILINEAR
REGRESSION ANALYSIS BY RATING

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EM RATING

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POLYNOMIAL FITTING FOR    2 VARIABLES-SRE AND TP SCORE-    97 OBSERVATIONS.

THE PREDICTOR VARIABLE(X) IS SRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.413      0.302
 2   SQUAR         0.260      0.276
 3   X CUBE        0.185      0.258
 4      Y          6.000      1.953
CORRELATION MATRIX
 1      X          1.000      0.945      0.867      0.365
 2   SQUAR         0.945      1.000      0.980      0.364
 3   X CUBE        0.867      0.980      1.000      0.328
 4      Y          0.365      0.364      0.328      1.000
========================================================================
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS,
========================================================================
MULTIPLE R SQUARE =    0.133
MULTIPLE R =    0.365
N.D.F.1 =   1
N.D.F.2 =          95
F FOR ANALYSIS OF VARIANCE ON R =      14.560
BETA WEIGHTS
  0.365
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X          0.133      1.000
SQUARED BETA WEIGHTS
  0.133
B WEIGHTS
  2.358
INTERCEPT CONSTANT =      5.027
========================================================================
MULTIPLE R SQUARE =    0.136
MULTIPLE R =    0.369
N.D.F.1 =   2
N.D.F.2 =          94
F FOR ANALYSIS OF VARIANCE ON R =       7.420
BETA WEIGHTS
  0.196   0.179
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X          0.071      0.987
   2   SQUAR         0.065      0.985
SQUARED BETA WEIGHTS
  0.038   0.032
B WEIGHTS
  1.265   1.266
INTERCEPT CONSTANT =      5.148
========================================================================
MULTIPLE R SQUARE =    0.176
MULTIPLE R =    0.419
N.D.F.1 =   3
N.D.F.2 =          93
F FOR ANALYSIS OF VARIANCE ON R =      6.615
BETA WEIGHTS
 -1.120   3.778  -2.404
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X         -0.408      0.869
   2   SQUAR         1.374      0.867
   3   X CUBE       -0.790      0.783
SQUARED BETA WEIGHTS
  1.255  14.276   5.779
B WEIGHTS
 -7.246  26.735 -18.221
INTERCEPT CONSTANT =      5.404

ANOVA TABLE FOR POLYNOMIALS
========================================================================
REDUCTION DUE TO LINEAR FIT, WITH 1 DF =       0.133
RESIDUAL S.S. =      0.867  DF =      95  RESIDUAL M.S. =      0.009
F FOR LINEAR FIT =   14.560
========================================================================

REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =      0.136
REDUCTION M.S. =      0.068
RESIDUAL S.S. =      0.864  DF =      94  RESIDUAL M.S. =      0.009
F FOR QUADRATIC FIT =    7.420
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =      0.003
F FOR QUADRATIC TERM ALONE =    0.375
========================================================================

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =      0.176
REDUCTION M.S. =      0.059
RESIDUAL S.S. =      0.824  DF =      93  RESIDUAL M.S. =      0.009
F FOR GENERAL CUBIC FIT =     6.615
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =      0.040
F FOR CUBIC TERM ALONE =    4.460
========================================================================
```

POLYNOMIAL FITTING FOR 2 VARIABLES-PRE AND TP SCORE. 97 OBSERVATIONS.

EM RATING

THE PREDICTOR VARIABLE(X) IS PRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

```
TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.681       0.370
 2   SQUAR         0.599       0.364
 3   X CUBE        0.539       0.359
 4      Y          6.000       1.953
CORRELATION MATRIX
 1      X          1.000       0.979       0.942       0.247
 2   SQUAR         0.979       1.000       0.990       0.297
 3   X CUBE        0.942       0.990       1.000       0.322
 4      Y          0.247       0.297       0.322       1.000
================================================================
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
================================================================
MULTIPLE R SQUARE =     0.061
MULTIPLE R =    0.247
N.D.F.1 =    1
N.D.F.2 =         95
F FOR ANALYSIS OF VARIANCE ON R =        6.163
BETA WEIGHTS
  0.247
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1    X          0.061       1.000
SQUARED BETA WEIGHTS
  0.061
B WEIGHTS
  1.303
INTERCEPT CONSTANT =      5.112
================================================================
MULTIPLE R SQUARE =     0.133
MULTIPLE R =    0.365
N.D.F.1 =    2
N.D.F.2 =         94
F FOR ANALYSIS OF VARIANCE ON R =        7.238
BETA WEIGHTS
 -1.033   1.367
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1    X         -0.255       0.676
   2   SQUAR       0.388       0.813
SQUARED BETA WEIGHTS
  1.066   1.769
B WEIGHTS
 -5.453   7.004
INTERCEPT CONSTANT =      5.516
================================================================
MULTIPLE R SQUARE =     0.133
MULTIPLE R =    0.365
N.D.F.1 =    3
N.D.F.2 =         93
F FOR ANALYSIS OF VARIANCE ON R =        4.774
BETA WEIGHTS
 -1.006   1.241   0.041
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1    X         -0.248       0.676
   2   SQUAR       0.368       0.813
   3   X CUBE      0.013       0.882
SQUARED BETA WEIGHTS
  1.012   1.539   0.002
B WEIGHTS
 -5.313   6.647   0.224
INTERCEPT CONSTANT =      5.515


ANOVA TABLE FOR POLYNOMIALS
================================================================
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.061
 RESIDUAL S.S. =       0.939  DF =      95  RESIDUAL M.S. =       0.010
F FOR LINEAR FIT =     6.163
================================================================

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =       0.133
REDUCTION M.S. =        0.067
 RESIDUAL S.S. =        0.867  DF =      94  RESIDUAL M.S. =       0.009
F FOR QUADRATIC FIT =     7.238
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =       0.073
F FOR QUADRATIC TERM ALONE =     7.867
================================================================

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =       0.133
REDUCTION M.S. =        0.044
 RESIDUAL S.S. =        0.867  DF =      93  RESIDUAL M.S. =       0.009
F FOR GENERAL CUBIC FIT =     4.774
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =        0.000
F FOR CUBIC TERM ALONE =    0.000
================================================================
```

```
POLYNOMIAL FITTING FOR    2 VARIABLES-GRE AND TP SCORE-    97 OBSERVATIONS,
```

EM RATING

```
THE PREDICTOR VARIABLE(X) IS GRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE,

TEST MEANS AND STANDARD DEVIATIONS
 1     X          0.960        0.051
 2   SQUAR        0.924        0.093
 3   X CUBE       0.891        0.129
 4     Y          6.000        1.953
CORRELATION MATRIX
 1     X          1.000        0.999        0.997        0.301
 2   SQUAR        0.999        1.000        0.999        0.311
 3   X CUBE       0.997        0.999        1.000        0.321
 4     Y          0.301        0.311        0.321        1.000
*****************************************************************************
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS,
*****************************************************************************
MULTIPLE R SQUARE =    0.090
MULTIPLE R =    0.301
N.D.F.1 =    1
N.O.F.2 =         95
F FOR ANALYSIS OF VARIANCE ON R =       9.435
BETA WEIGHTS
 0.301
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1     X          0.090        1.000
SQUARED BETA WEIGHTS
 0.090
B WEIGHTS
 11.507
INTERCEPT CONSTANT =     -5.043
*****************************************************************************
MULTIPLE R SQUARE =    0.154
MULTIPLE R =    0.393
N.D.F.1 =    2
N.D.F.2 =         94
F FOR ANALYSIS OF VARIANCE ON R =       8.560
BETA WEIGHTS
 -5.585   5.891
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1     X         -1.679        0.766
   2   SQUAR        1.833        0.793
SQUARED BETA WEIGHTS
 31.196  34.707
B WEIGHTS
213.819 123.123
INTERCEPT CONSTANT =     97.486
*****************************************************************************
MULTIPLE R SQUARE =    0.221
MULTIPLE R =    0.470
N.D.F.1 =    3
N.D.F.2 =         93
F FOR ANALYSIS OF VARIANCE ON R =       8.794
BETA WEIGHTS
127.159-266.409 139.994
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1     X         38.221        0.639
   2   SQUAR      -82.947        0.662
   3   X CUBE      44.947        0.683
SQUARED BETA WEIGHTS
***********************
B WEIGHTS
867.907********2117.081
INTERCEPT CONSTANT = -1409.053


ANOVA TABLE FOR POLYNOMIALS
*****************************************************************************
REDUCTION DUE TO LINEAR FIT, WITH 1 OF =       0.090
RESIDUAL S.S. =       0.910   OF =      95  RESIDUAL M.S. =       0.010
F FOR LINEAR FIT =    9.435
*****************************************************************************

REDUCTION DUE TO GENERAL QUADRATIC FIT WITH OF 2, =       0.154
REDUCTION M.S. =       0.077
RESIDUAL S.S. =       0.846   OF =      94  RESIDUAL M.S. =       0.009
F FOR QUADRATIC FIT =    8.560
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =       0.064
F FOR QUADRATIC TERM ALONE =    7.081
*****************************************************************************

REDUCTION DUE TO GENERAL CUBIC FIT WITH OF 3, =       0.221
REDUCTION M.S. =       0.074
RESIDUAL S.S. =       0.779   DF =      93  RESIDUAL M.S. =       0.008
F FOR GENERAL CUBIC FIT =    8.794
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 OF =       0.067
F FOR CUBIC TERM ALONE =    7.987
*****************************************************************************
```

EM RATING

```
=============================================================================
POLYNOMIAL FITTING FOR    2 VARIABLES-WRE AND TP SCORE-    97 OBSERVATIONS.

THE PREDICTOR VARIABLE(X) IS WRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.647        0.185
 2    SQUAR        0.453        0.225
 3    X CUBE       0.333        0.236
 4      Y          6.000        1.953
CORRELATION MATRIX
 1      X          1.000        0.963        0.918        0.492
 2    SQUAR        0.963        1.000        0.989        0.504
 3    X CUBE       0.918        0.989        1.000        0.481
 4      Y          0.492        0.504        0.481        1.000
=============================================================================
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
=============================================================================
MULTIPLE R SQUARE =     0.242
MULTIPLE R =     0.492
N.D.F.1 =    1
N.D.F.2 =          95
F FOR ANALYSIS OF VARIANCE ON R =       30.345
BETA WEIGHTS
  0.492
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1     X         0.242       1.000
SQUARED BETA WEIGHTS
  0.242
B WEIGHTS
  5.194
INTERCEPT CONSTANT =       2.639
=============================================================================
MULTIPLE R SQUARE =     0.254
MULTIPLE R =     0.504
N.D.F.1 =    2
N.D.F.2 =          94
F FOR ANALYSIS OF VARIANCE ON R =       16.024
BETA WEIGHTS
  0.096   0.411
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1     X         0.047       0.976
   2   SQUAR       0.207       0.999
SQUARED BETA WEIGHTS
  0.009   0.169
B WEIGHTS
  1.012   3.573
INTERCEPT CONSTANT =       3.728
=============================================================================
MULTIPLE R SQUARE =     0.300
MULTIPLE R =     0.548
N.D.F.1 =    3
N.D.F.2 =          93
F FOR ANALYSIS OF VARIANCE ON R =       13.273
BETA WEIGHTS
 -1.475   5.100  -3.210
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1     X        -0.726       0.899
   2   SQUAR       2.568       0.920
   3   X CUBE     -1.543       0.878
SQUARED BETA WEIGHTS
  2.176  26.012  10.307
B WEIGHTS
-15.571  44.319 -26.561
INTERCEPT CONSTANT =       4.849


 ANOVA TABLE FOR POLYNOMIALS
=============================================================================
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =         0.242
 RESIDUAL S.S. =        0.758   DF =        95  RESIDUAL M.S. =        0.008
F FOR LINEAR FIT =    30.345
=============================================================================

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =          0.254
REDUCTION M.S. =        0.127
 RESIDUAL S.S. =        0.746   DF =        94  RESIDUAL M.S. =        0.008
F FOR QUADRATIC FIT =    16.024
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.012
F FOR QUADRATIC TERM ALONE =      1.532
=============================================================================

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.300
REDUCTION M.S. =        0.100
 RESIDUAL S.S. =        0.700   DF =        93  RESIDUAL M.S. =        0.008
F FOR GENERAL CUBIC FIT =    13.273
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =        0.046
F FOR CUBIC TERM ALONE =    6.051
=============================================================================
```

ET RATING

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--------------------------------------------------------------------------------
POLYNOMIAL FITTING FOR    2 VARIABLES-SRE AND TP SCORE.   173 OBSERVATIONS.


THE PREDICTOR VARIABLE(X) IS SRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.


TEST MEANS AND STANDARD DEVIATIONS
 1       X          0.168       0.208
 2    SQUAR         0.071       0.149
 3    X CUBE        0.040       0.127
 4       Y          6.514       1.784
CORRELATION MATRIX
 1       X          1.000       0.909       0.778       0.318
 2    SQUAR         0.909       1.000       0.963       0.205
 3    X CUBE        0.778       0.963       1.000       0.126
 4       Y          0.318       0.205       0.126       1.000
--------------------------------------------------------------------------------
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
--------------------------------------------------------------------------------
MULTIPLE R SQUARE =    0.101
MULTIPLE R =     0.318
N.D.F.1 =   1
N.D.F.2 =          171
F FOR ANALYSIS OF VARIANCE ON R =      19.191
BETA WEIGHTS
  0.318
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X          0.101       1.000
SQUARED BETA WEIGHTS
  0.101
B WEIGHTS
  2.720
INTERCEPT CONSTANT =      6.057
--------------------------------------------------------------------------------
MULTIPLE R SQUARE =    0.142
MULTIPLE R =     0.376
N.D.F.1 =   2
N.D.F.2 =          170
F FOR ANALYSIS OF VARIANCE ON R =      14.021
BETA WEIGHTS
  0.759  -0.485
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X          0.241       0.844
   2    SQUAR        -0.099       0.545
SQUARED BETA WEIGHTS
  0.576   0.235
B WEIGHTS
  6.498  -5.709
INTERCEPT CONSTANT =      5.835
--------------------------------------------------------------------------------
MULTIPLE R SQUARE =    0.142
MULTIPLE R =     0.377
N.D.F.1 =   3
N.D.F.2 =          169
F FOR ANALYSIS OF VARIANCE ON R =      9.323
BETA WEIGHTS
  0.845  -0.710   0.152
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X          0.268       0.893
   2    SQUAR        -0.145       0.544
   3    X CUBE        0.019       0.334
SQUARED BETA WEIGHTS
  0.714   0.504   0.023
B WEIGHTS
  7.235  -8.477   2.129
INTERCEPT CONSTANT =      5.817


 ANOVA TABLE FOR POLYNOMIALS
--------------------------------------------------------------------------------
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =      0.101
 RESIDUAL S.S. =       0.899   DF =      171   RESIDUAL M.S. =       0.005
F FOR LINEAR FIT =    19.191
--------------------------------------------------------------------------------

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =      0.142
REDUCTION M.S. =       0.071
 RESIDUAL S.S. =       0.858   DF =      170   RESIDUAL M.S. =       0.005
F FOR QUADRATIC FIT =    14.021
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =      0.041
F FOR QUADRATIC TERM ALONE =     8.058
--------------------------------------------------------------------------------

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =      0.142
REDUCTION M.S. =       0.047
 RESIDUAL S.S. =       0.858   DF =      169   RESIDUAL M.S. =       0.005

F FOR GENERAL CUBIC FIT =     9.323
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,      0.000
F FOR CUBIC TERM ALONE =    0.078
--------------------------------------------------------------------------------
```

```
POLYNOMIAL FITTING FOR    2 VARIABLES-PRE AND TP SCORE.   173 OBSERVATIONS.
```

ET RATING

```
THE PREDICTOR VARIABLE(X) IS PRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.404       0.352
 2   SQUAR         0.287       0.288
 3   X CUBE        0.213       0.248
 4      Y          6.514       1.784
CORRELATION MATRIX
 1      X          1.000       0.967       0.904       0.366
 2   SQUAR         0.967       1.000       0.982       0.361
 3   X CUBE        0.904       0.982       1.000       0.343
 4      Y          0.366       0.361       0.343       1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.134
MULTIPLE R =    0.36'
N.D.F.1 =    1
N.D.F.2 =       171
F FOR ANALYSIS OF VARIANCE ON R =      26.423
BETA WEIGHTS
  0.366
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
   1      X         0.134       1.000
SQUARED BETA WEIGHTS
  0.134
B WEIGHTS
  1.854
INTERCEPT CONSTANT =      5.765
MULTIPLE R SQUARE =     0.135
MULTIPLE R =     0.367
N.D.F.1 =    2
N.D.F.2 =       170
F FOR ANALYSIS OF VARIANCE ON R =      13.222
BETA WEIGHTS
  0.260    0.109
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
   1      X         0.095       0.997
   2    SQUAR       0.039       0.984
SQUARED BETA WEIGHTS
  0.068    0.012
B WEIGHTS
  1.319    0.677
INTERCEPT CONSTANT =      5.787
MULTIPLE R SQUARE =     0.135
MULTIPLE R =     0.367
N.D.F.1 =    3
N.D.F.2 =       169
F FOR ANALYSIS OF VARIANCE ON R =       8.769
BETA WEIGHTS
  0.364   -0.137   0.148
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
   1      X         0.133       0.997
   2    SQUAR      -0.049       0.983
   3    X CUBE      0.051       0.935
SQUARED BETA WEIGHTS
  0.133    0.019    0.022
B WEIGHTS
  1.845   -0.847   1.068
INTERCEPT CONSTANT =      5.783

 ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =       0.134
 RESIDUAL S.S. =       0.866   DF =     171   RESIDUAL M.S. =       0.005
F FOR LINEAR FIT =    26.423

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =       0.135
REDUCTION M.S. =       0.067
RESIDUAL S.S. =        0.865   DF =     170   RESIDUAL M.S. =       0.005
F FOR QUADRATIC FIT =    13.222
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =       0.001
F FOR QUADRATIC TERM ALONE =     0.152

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =       0.135
REDUCTION M.S. =       0.045
RESIDUAL S.S. =        0.865   DF =     169   RESIDUAL M.S. =       0.005
F FOR GENERAL CUBIC FIT =     8.769
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =  ,     0.000
F FOR CUBIC TERM ALONE =     0.017
```

ET RATING

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==========================================================================
POLYNOMIAL FITTING FOR     2 VARIABLES-GRE AND TP SCORE.    173 OBSERVATIONS.


THE PREDICTOR VARIABLE(X) IS GRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE,


TEST MEANS AND STANDARD DEVIATIONS
 1       X          0.864        0.222
 2   SQUAR          0.796        0.245
 3   X CUBE         0.740        0.272
 4       Y          6.514        1.784
CORRELATION MATRIX
 1       X          1.000        0.960        0.893        0.508
 2   SQUAR          0.960        1.000        0.984        0.512
 3   X CUBE         0.893        0.984        1.000        0.495
 4       Y          0.508        0.512        0.499        1.000
==========================================================================
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
==========================================================================
MULTIPLE R SQUARE =     0.258
MULTIPLE R =     0.508
N.D.F.1 =    1
N.D.F.2 =          171
F FOR ANALYSIS OF VARIANCE ON R =       59.470
BETA WEIGHTS
  0.508
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X        0.258        1.000
SQUARED BETA WEIGHTS
  0.258
B WEIGHTS
  4.080
INTERCEPT CONSTANT =       2.988
==========================================================================
MULTIPLE R SQUARE =     0.266
MULTIPLE R =     0.515
N.D.F.1 =    2
N.D.F.2 =          170
F FOR ANALYSIS OF VARIANCE ON R =       30.763
BETA WEIGHTS
  0.209    0.312
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X        0.106        0.985
   2   SQUAR        0.160        0.993
SQUARED BETA WEIGHTS
  0.044    0.097
B WEIGHTS
  1.676    2.274
INTERCEPT CONSTANT =       3.255
==========================================================================
MULTIPLE R SQUARE =     0.271
MULTIPLE R =     0.521
N.D.F.1 =    3
N.D.F.2 =          169
F FOR ANALYSIS OF VARIANCE ON R =       20.966
BETA WEIGHTS
  2.199  -4.675   3.129
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X        1.117        0.975
   2   SQUAR       -2.394        0.983
   3   X CUBE       1.549        0.950
SQUARED BETA WEIGHTS
  4.837  21.859   9.788
B WEIGHTS
 17.664 -34.085  20.481
INTERCEPT CONSTANT =       3.227


 ANOVA TABLE FOR POLYNOMIALS
==========================================================================
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =          0.258
 RESIDUAL S.S. =          0.742  DF =      171  RESIDUAL M.S. =        0.004
F FOR LINEAR FIT =    59.470
==========================================================================

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.266
REDUCTION M.S. =          0.133
 RESIDUAL S.S. =          0.734  DF =      170  RESIDUAL M.S. =        0.004
F FOR QUADRATIC FIT =    30.763
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.008
F FOR QUADRATIC TERM ALONE =     1.783
==========================================================================

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.271
REDUCTION M.S. =          0.090
 RESIDUAL S.S. =          0.729  DF =      169  RESIDUAL M.S. =        0.004

F FOR GENERAL CUBIC FIT =    20.966
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,       0.005
F FOR CUBIC TERM ALONE =     1.274
==========================================================================
```

ET RATING

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POLYNOMIAL FITTING FOR    2 VARIABLES-WRE AND TP SCORE-   173 OBSERVATIONS.

THE PREDICTOR VARIABLE(X) IS WRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1       X           0.573        0.210
 2    SQUAR          0.372        0.225
 3    X CUBE         0.259        0.207
 4       Y           6.514        1.784
CORRELATION MATRIX
 1       X           1.000        0.977        0.932        0.445
 2    SQUAR          0.977        1.000        0.987        0.413
 3    X CUBE         0.932        0.987        1.000        0.380
 4       Y           0.445        0.413        0.380        1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.198
MULTIPLE R =     0.445
N.D.F.1 =    1
N.D.F.2 =        171
F FOR ANALYSIS OF VARIANCE ON R =       42.260
BETA WEIGHTS
  0.445
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS.  2ND COLUMN)
   1       X          0.198        1.000
SQUARED BETA WEIGHTS
  0.198
B WEIGHTS
  3.789
INTERCEPT CONSTANT =       4.344
MULTIPLE R SQUARE =     0.209
MULTIPLE R =     0.457
N.D.F.1 =    2
N.D.F.2 =        170
F FOR ANALYSIS OF VARIANCE ON R =       22.416
BETA WEIGHTS
  0.913  -0.479
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS.  2ND COLUMN)
   1       X          0.406        0.974
   2    SQUAR        -0.198        0.904
SQUARED BETA WEIGHTS
  0.833   0.229
B WEIGHTS
  7.769  -3.842
INTERCEPT CONSTANT =     [illegible].478
MULTIPLE R SQUARE =     [illegible]10
MULTIPLE R =     0.458
N.D.F.1 =    3
N.D.F.2 =        169
F FOR ANALYSIS OF VARIANCE ON R =       14.942
BETA WEIGHTS
  1.285  -1.349   0.534
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS.  2ND COLUMN)
   1       X          0.572        0.972
   2    SQUAR        -0.565        0.902
   3    X CUBE        0.203        0.830
SQUARED BETA WEIGHTS
  1.651   1.875   0.285
B WEIGHTS
 10.937 -10.877   4.602
INTERCEPT CONSTANT =       3.103

  ANOVA TABLE FOR POLYNOMIALS
  REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.198
  RESIDUAL S.S. =        0.802   DF =      171   RESIDUAL M.S. =        0.005
F FOR LINEAR FIT =    42.260

  REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.209
REDUCTION M.S. =        0.104
  RESIDUAL S.S. =        0.791   DF =      170   RESIDUAL M.S. =        0.005
F FOR QUADRATIC FIT =    22.416
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF. =        0.011
F FOR QUADRATIC TERM ALONE =     2.261

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.210
REDUCTION M.S. =        0.070
  RESIDUAL S.S. =        0.790   DF =      169   RESIDUAL M.S. =        0.005
F FOR GENERAL CUBIC FIT =    14.942
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,       0.001
F FOR CUBIC TERM ALONE =     0.204
```

FT RATING

```
POLYNOMIAL FITTING FOR    2 VARIABLES-SRE AND TP SCORE-   154 OBSERVATIONS.

THE PREDICTOR VARIABLE(X) IS SRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1       X          0.303        0.293
 2    SQUAR         0.177        0.255
 3    X CUBE        0.124        0.231
 4       Y          6.240        2.042
CORRELATION MATRIX
 1       X          1.000        0.944        0.871        0.346
 2    SQUAR         0.944        1.000        0.981        0.322
 3    X CUBE        0.871        0.981        1.000        0.294
 4       Y          0.346        0.322        0.294        1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.119
MULTIPLE R =     0.346
N.D.F.1 =    1
N.D.F.2 =         152
F FOR ANALYSIS OF VARIANCE ON R =        20.623
BETA WEIGHTS
  0.346
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS.  2ND COLUMN)
   1       X         0.119        1.000
SQUARED BETA WEIGHTS
  0.119
B WEIGHTS
  2.410
INTERCEPT CONSTANT =       5.509
MULTIPLE R SQUARE =     0.120
MULTIPLE R =     0.346
N.D.F.1 =    2
N.D.F.2 =         151
F FOR ANALYSIS OF VARIANCE ON R =        10.259
BETA WEIGHTS
  0.382  -0.038
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS.  2ND COLUMN)
   1       X         0.132        0.999
   2    SQUAR       -0.012        0.932
SQUARED BETA WEIGHTS
  0.146   0.001
B WEIGHTS
  2.663  -0.307
INTERCEPT CONSTANT =       5.467
MULTIPLE R SQUARE =     0.120
MULTIPLE R =     0.346
N.D.F.1 =    3
N.D.F.2 =         150
F FOR ANALYSIS OF VARIANCE ON R =        6.798
BETA WEIGHTS
  0.339   0.093  -0.083
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS.  2ND COLUMN)
   1       X         0.117        0.999
   2    SQUAR        0.027        0.932
   3    X CUBE      -0.024        0.850
SQUARED BETA WEIGHTS
  0.115   0.007   0.007
B WEIGHTS
  2.364   0.665  -0.730
INTERCEPT CONSTANT =       5.495

ANOVA TABLE FOR POLYNOMIALS
REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.119
RESIDUAL S.S. =        0.881  DF =       152  RESIDUAL M.S. =       0.006
F FOR LINEAR FIT =    20.623

REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =       0.120
REDUCTION M.S. =        0.060
RESIDUAL S.S. =        0.880  DF =       151  RESIDUAL M.S. =       0.006
F FOR QUADRATIC FIT =    10.259
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =       0.000
F FOR QUADRATIC TERM ALONE =     0.027

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =       0.120
REDUCTION M.S. =        0.040
RESIDUAL S.S. =        0.880  DF =       150  RESIDUAL M.S. =       0.006
F FOR GENERAL CUBIC FIT =     6.798
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,      0.000
F FOR CUBIC TERM ALONE =     0.010
```

POLYNOMIAL FITTING FOR 2 VARIABLES-PRE AND TP SCORE- 154 OBSERVATIONS.

FT RATING

THE PREDICTOR VARIABLE(X) IS PRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS

1	X	0.568	0.393
2	SQUAR	0.476	0.365
3	X CUBE	0.410	0.347
4	Y	6.240	2.042

CORRELATION MATRIX

1	X	1.000	0.976	0.931	0.264
2	SQUAR	0.976	1.000	0.987	0.296
3	X CUBE	0.931	0.987	1.000	0.312
4	Y	0.264	0.296	0.312	1.000

FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.

MULTIPLE R SQUARE = 0.070
MULTIPLE R = 0.264
N.D.F.1 = 1
N.D.F.2 = 152
F FOR ANALYSIS OF VARIANCE ON R = 11.394
BETA WEIGHTS
0.264
CONTRIBUTIONS TO MULTIPLE CORRELATION
AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
1 X 0.070 1.000
SQUARED BETA WEIGHTS
0.070
B WEIGHTS
1.372
INTERCEPT CONSTANT = 5.460

MULTIPLE R SQUARE = 0.100
MULTIPLE R = 0.317
N.D.F.1 = 2
N.D.F.2 = 151
F FOR ANALYSIS OF VARIANCE ON R = 8.408
BETA WEIGHTS
-0.524 0.807
CONTRIBUTIONS TO MULTIPLE CORRELATION
AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
1 X -0.138 0.834
2 SQUAR 0.239 0.934
SQUARED BETA WEIGHTS
0.275 0.652
B WEIGHTS
-2.724 4.520
INTERCEPT CONSTANT = 5.635

MULTIPLE R SQUARE = 0.104
MULTIPLE R = 0.322
N.D.F.1 = 3
N.D.F.2 = 150
F FOR ANALYSIS OF VARIANCE ON R = 5.784
BETA WEIGHTS
0.394 -1.375 1.303
CONTRIBUTIONS TO MULTIPLE CORRELATION
AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
1 X 0.104 0.820
2 SQUAR -0.407 0.918
3 X CUBE 0.406 0.968
SQUARED BETA WEIGHTS
0.155 1.892 1.697
B WEIGHTS
2.048 -7.699 7.657
INTERCEPT CONSTANT = 5.606

ANOVA TABLE FOR POLYNOMIALS

REDUCTION DUE TO LINEAR FIT, WITH 1 DF = 0.070
RESIDUAL S.S. = 0.930 DF = 152 RESIDUAL M.S. = 0.006
F FOR LINEAR FIT = 11.394

REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, = 0.100
REDUCTION M.S. = 0.050
RESIDUAL S.S. = 0.900 DF = 151 RESIDUAL M.S. = 0.006
F FOR QUADRATIC FIT = 8.408
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, = 0.030
F FOR QUADRATIC TERM ALONE = 5.114

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, = 0.104
REDUCTION M.S. = 0.035
RESIDUAL S.S. = 0.896 DF = 150 RESIDUAL M.S. = 0.006
F FOR GENERAL CUBIC FIT = 5.784
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = 0.003
F FOR CUBIC TERM ALONE = 0.582

FT RATING

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POLYNOMIAL FITTING FOR   2 VARIABLES-GRE AND TP SCORE-   154 OBSERVATIONS.


THE PREDICTOR VARIABLE(X) IS GRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.


TEST MEANS AND STANDARD DEVIATIONS
 1       X          0.932        0.071
 2    SQUAR         0.873        0.125
 3    X CUBE        0.822        0.170
 4       Y          6.240        2.042
CORRELATION MATRIX
 1       X          1.000        0.997        0.991        0.374
 2    SQUAR         0.997        1.000        0.998        0.380
 3    X CUBE        0.991        0.998        1.000        0.382
 4       Y          0.374        0.380        0.382        1.000
*****************************************************************************
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
*****************************************************************************
MULTIPLE R SQUARE =     0.140
MULTIPLE R =    0.374
N.D.F.1 =    1
N.D.F.2 =          152
F FOR ANALYSIS OF VARIANCE ON R =       24.721
BETA WEIGHTS
  0.374
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X        0.140        1.000
SQUARED BETA WEIGHTS
  0.140
B WEIGHTS
 10.818
INTERCEPT CONSTANT =     -3.840
*****************************************************************************
MULTIPLE R SQUARE =     0.148
MULTIPLE R =    0.385
N.D.F.1 =    2
N.D.F.2 =          151
F FOR ANALYSIS OF VARIANCE ON R =       13.156
BETA WEIGHTS
 -0.926   1.304
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X       -0.346        0.971
   2   SQUAR        0.495        0.985
SQUARED BETA WEIGHTS
  0.858   1.699
B WEIGHTS
-26.793  21.215
INTERCEPT CONSTANT =      12.681
*****************************************************************************
MULTIPLE R SQUARE =     0.165
MULTIPLE R =    0.406
N.D.F.1 =    3
N.D.F.2 =          150
F FOR ANALYSIS OF VARIANCE ON R =        9.871
BETA WEIGHTS
-24.807  52.818 -27.746
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X       -9.278        0.921
   2   SQUAR       20.050        0.935
   3   X CUBE     -10.607        0.942
SQUARED BETA WEIGHTS
615.3702789.744 769.824
B WEIGHTS
717.524 859.598-334.275
INTERCEPT CONSTANT =   199.144


 ANOVA TABLE FOR POLYNOMIALS
*****************************************************************************
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.140
 RESIDUAL S.S. =        0.860  DF =      152  RESIDUAL M.S. =        0.006
F FOR LINEAR FIT =   24.721
*****************************************************************************

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.148
REDUCTION M.S. =        0.074
 RESIDUAL S.S. =        0.852  DF =      151  RESIDUAL M.S. =        0.006
F FOR QUADRATIC FIT =    13.156
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.009
F FOR QUADRATIC TERM ALONE =      1.508
*****************************************************************************

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.165
REDUCTION M.S. =        0.055
 RESIDUAL S.S. =        0.835  DF =      150  RESIDUAL M.S. =        0.006
F FOR GENERAL CUBIC FIT =      9.871
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =        0.018
F FOR CUBIC TERM ALONE =     2.959
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POLYNOMIAL FITTING FOR    2 VARIABLES-WRE AND TP SCORE-   154 OBSERVATIONS.
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FT RATING

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THE PREDICTOR VARIABLE(X) IS WRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.


TEST MEANS AND STANDARD DEVIATIONS
 1       X            0.420        0.190
 2    SQUAR           0.420        0.215
 3    X CUBE          0.300        0.211
 4       Y            6.240        2.042
CORRELATION MATRIX
 1       X            1.000        0.970        0.919        0.430
 2    SQUAR           0.970        1.000        0.984        0.388
 3    X CUBE          0.919        0.986        1.000        0.344
 4       Y            0.430        0.388        0.344        1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.185
MULTIPLE R =    0.430
N.D.F.1 =    1
N.D.F.2 =          152
F FOR ANALYSIS OF VARIANCE ON R =      34.532
BETA WEIGHTS
  0.430
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS.  2ND COLUMN)
   1      X          0.185        1.000
SQUARED BETA WEIGHTS
  0.185
B WEIGHTS
  4.635
INTERCEPT CONSTANT =      3.366
MULTIPLE R SQUARE =     0.200
MULTIPLE R =    0.448
N.D.F.1 =    2
N.D.F.2 =          151
F FOR ANALYSIS OF VARIANCE ON R =      18.907
BETA WEIGHTS
  0.923  -0.508
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS.  2ND COLUMN)
   1      X          0.397        0.961
   2    SQUAR       -0.197        0.866
SQUARED BETA WEIGHTS
  0.852   0.258
B WEIGHTS
  9.943  -4.832
INTERCEPT CONSTANT =      2.105
MULTIPLE R SQUARE =     0.204
MULTIPLE R =    0.451
N.D.F.1 =    3
N.D.F.2 =          150
F FOR ANALYSIS OF VARIANCE ON R =      12.786
BETA WEIGHTS
  0.328   0.984  -0.928
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS.  2ND COLUMN)
   1      X          0.141        0.953
   2    SQUAR        0.382        0.859
   3    X CUBE      -0.319        0.762
SQUARED BETA WEIGHTS
  0.107   0.969   0.861
B WEIGHTS
  3.531   9.365  -8.994
INTERCEPT CONSTANT =      2.811


 ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.185
 RESIDUAL S.S. =        0.815   DF =      152   RESIDUAL M.S. =       0.005
F FOR LINEAR FIT =    34.532

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.200
REDUCTION M.S. =        0.100
 RESIDUAL S.S. =        0.800   DF =      151   RESIDUAL M.S. =       0.005
F FOR QUADRATIC FIT =    18.907
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.015
F FOR QUADRATIC TERM ALONE =      2.860

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.204
REDUCTION M.S. =        0.068
 RESIDUAL S.S. =        0.796   DF =      150   RESIDUAL M.S. =       0.005
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F FOR GENERAL CUBIC FIT =    12.786
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =        0.003
F FOR CUBIC TERM ALONE =      0.635
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POLYNOMIAL FITTING FOR     2 VARIABLES-SRE AND TP SCORE-     58 OBSERVATIONS.
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IC RATING

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THE PREDICTOR VARIABLE(X) IS SRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1        X          0.266        0.280
 2    SQUAR          0.148        0.220
 3   X CUBE          0.096        0.189
 4        Y          5.552        2.371
CORRELATION MATRIX
 1        X          1.000        0.941        0.846        0.361
 2    SQUAR          0.941        1.000        0.973        0.345
 3   X CUBE          0.846        0.973        1.000        0.309
 4        Y          0.361        0.345        0.309        1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.131
MULTIPLE R =     0.361
N.D.F.1 =     1
N.D.F.2 =            56
F FOR ANALYSIS OF VARIANCE ON R =       8.407
BETA WEIGHTS
  0.361
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1        X          0.131        1.000
SQUARED BETA WEIGHTS
  0.131
B WEIGHTS
  3.062
INTERCEPT CONSTANT =      4.738
MULTIPLE R SQUARE =     0.131
MULTIPLE R =     0.362
N.D.F.1 =     2
N.D.F.2 =            55
F FOR ANALYSIS OF VARIANCE ON R =       4.136
BETA WEIGHTS
  0.320   0.044
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1        X          0.116        0.999
   2    SQUAR          0.015        0.954
SQUARED BETA WEIGHTS
  0.102   0.002
B WEIGHTS
  2.711   0.474
INTERCEPT CONSTANT =      4.761
MULTIPLE R SQUARE =     0.133
MULTIPLE R =     0.364
N.D.F.1 =     3
N.D.F.2 =            54
F FOR ANALYSIS OF VARIANCE ON R =       2.755
BETA WEIGHTS
  0.063   0.698  -0.423
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1        X          0.023        0.992
   2    SQUAR          0.241        0.947
   3   X CUBE         -0.131        0.847
SQUARED BETA WEIGHTS
  0.004   0.487   0.179
B WEIGHTS
  0.534   7.500  -5.306
INTERCEPT CONSTANT =      4.814

 ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.131
 RESIDUAL S.S. =        0.869   DF =      56   RESIDUAL M.S. =        0.016
F FOR LINEAR FIT =     8.407

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.131
REDUCTION M.S. =        0.065
RESIDUAL S.S. =        0.869   DF =      55   RESIDUAL M.S. =        0.016
F FOR QUADRATIC FIT =      4.136
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.000
F FOR QUADRATIC TERM ALONE =      0.014

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.133
REDUCTION M.S. =        0.044
RESIDUAL S.S. =        0.867   DF =      54   RESIDUAL M.S. =        0.016

F FOR GENERAL CUBIC FIT =     2.755
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,       0.002
F FOR CUBIC TERM ALONE =     0.125
```

IC RATING

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POLYNOMIAL FITTING FOR    2 VARIABLES-PRE AND TP SCORE-    58 OBSERVATIONS.

THE PREDICTOR VARIABLE(X) IS PRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.508        0.399
 2   SQUAR         0.414        0.365
 3   X CUBE        0.350        0.341
 4      Y          5.552        2.371
CORRELATION MATRIX
 1      X          1.000        0.976        0.936        0.322
 2   SQUAR         0.976        1.000        0.989        0.350
 3   X CUBE        0.936        0.989        1.000        0.362
 4      Y          0.322        0.350        0.362        1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =    0.104
MULTIPLE R =    0.322
N.D.F.1 =    1
N.D.F.2 =         56
F FOR ANALYSIS OF VARIANCE ON R =        6.493
BETA WEIGHTS
  0.322
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1    X          0.104        1.000
SQUARED BETA WEIGHTS
  0.104
B WEIGHTS
  1.914
INTERCEPT CONSTANT =       4.580
MULTIPLE R SQUARE =    0.131
MULTIPLE R =    0.362
N.D.F.1 =    2
N.D.F.2 =         55
F FOR ANALYSIS OF VARIANCE ON R =        4.142
BETA WEIGHTS
 -0.417   0.757
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1    X         -0.134        0.891
   2   SQUAR       0.265        0.968
SQUARED BETA WEIGHTS
  0.174   0.573
B WEIGHTS
 -2.475   4.912
INTERCEPT CONSTANT =       4.773
MULTIPLE R SQUARE =    0.134
MULTIPLE R =    0.367
N.D.F.1 =    3
N.D.F.2 =         54
F FOR ANALYSIS OF VARIANCE ON R =        2.796
BETA WEIGHTS
  0.378  -1.251   1.246
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1    X          0.122        0.879
   2   SQUAR      -0.438        0.955
   3   X CUBE      0.451        0.987
SQUARED BETA WEIGHTS
  0.143   1.565   1.552
B WEIGHTS
  2.245  -8.116   8.666
INTERCEPT CONSTANT =       4.739

ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =         0.104
 RESIDUAL S.S. =        0.896  DF =       56  RESIDUAL M.S. =        0.016
F FOR LINEAR FIT =      6.493

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.131
REDUCTION M.S. =        0.065
 RESIDUAL S.S. =        0.869  DF =       55  RESIDUAL M.S. =        0.016
F FOR QUADRATIC FIT =      4.142
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.027
F FOR QUADRATIC TERM ALONE =      1.709

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.134
REDUCTION M.S. =        0.045
 RESIDUAL S.S. =        0.866  DF =       54  RESIDUAL M.S. =        0.016
F FOR GENERAL CUBIC FIT =      2.796
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =        0.004
F FOR CUBIC TERM ALONE =      0.222
```

POLYNOMIAL FITTING FOR 2 VARIABLES-GRE AND TP SCORE. 58 OBSERVATIONS.

IC RATING

THE PREDICTOR VARIABLE(X) IS GRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

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TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.886        0.161
 2    SQUAR        0.811        0.214
 3    X CUBE       0.751        0.261
 4      Y          5.552        2.371
CORRELATION MATRIX
 1      X          1.000        0.954        0.901        0.387
 2    SQUAR        0.954        1.000        0.989        0.388
 3    X CUBE       0.901        0.989        1.000        0.381
 4      Y          0.387        0.388        0.381        1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =    0.149
MULTIPLE R =    0.387
N.D.F.1 =    1
N.D.F.2 =         56
F FOR ANALYSIS OF VARIANCE ON R =        9.838
BETA WEIGHTS
  0.387
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
   1      X        0.149        1.000
SQUARED BETA WEIGHTS
  0.149
B WEIGHTS
  5.706
INTERCEPT CONSTANT =      0.494
MULTIPLE R SQUARE =    0.154
MULTIPLE R =    0.392
N.D.F.1 =    2
N.D.F.2 =         55
F FOR ANALYSIS OF VARIANCE ON R =        4.995
BETA WEIGHTS
  0.178   0.219
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
   1      X        0.069        0.986
   2    SQUAR      0.085        0.991
SQUARED BETA WEIGHTS
  0.032   0.048
B WEIGHTS
  2.626   2.419
INTERCEPT CONSTANT =      1.263
MULTIPLE R SQUARE =    0.169
MULTIPLE R =    0.411
N.D.F.1 =    3
N.D.F.2 =         54
F FOR ANALYSIS OF VARIANCE ON R =        3.668
BETA WEIGHTS
  1.813  -4.772   3.467
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
   1      X        0.701        0.939
   2    SQUAR     -1.853        0.944
   3    X CUBE     1.322        0.927
SQUARED BETA WEIGHTS
  3.287  22.747  12.023
B WEIGHTS
 26.763 -52.768  31.515
INTERCEPT CONSTANT =      0.953

ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =       0.149
 RESIDUAL S.S. =       0.851   DF =       56   RESIDUAL M.S. =       0.015
F FOR LINEAR FIT =      9.838

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2. =       0.154
REDUCTION M.S. =       0.077
 RESIDUAL S.S. =       0.846   DF =       55   RESIDUAL M.S. =       0.015
F FOR QUADRATIC FIT =      4.995
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF. =       0.004
F FOR QUADRATIC TERM ALONE =      0.280

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3. =       0.169
REDUCTION M.S. =       0.056
 RESIDUAL S.S. =       0.831   DF =       54   RESIDUAL M.S. =       0.015
F FOR GENERAL CUBIC FIT =      3.668
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =       0.016
F FOR CUBIC TERM ALONE =    1.012
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POLYNOMIAL FITTING FOR    2 VARIABLES-WRE AND TP SCORE.    58 OBSERVATIONS.
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IC RATING

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THE PREDICTOR VARIABLE(X) IS WRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.542        0.190
 2   SQUAR         0.329        0.207
 3   X CUBE        0.216        0.189
 4      Y          5.552        2.371
CORRELATION MATRIX
 1      X          1.000        0.982        0.942        0.434
 2   SQUAR         0.982        1.000        0.988        0.382
 3   X CUBE        0.942        0.988        1.000        0.343
 4      Y          0.434        0.382        0.343        1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.188
MULTIPLE R =    0.434
N.D.F.1 =   1
N.D.F.2 =        56
F FOR ANALYSIS OF VARIANCE ON R =       12.997
BETA WEIGHTS
  0.434
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        0.188       1.000
SQUARED BETA WEIGHTS
  0.188
B WEIGHTS
  5.426
INTERCEPT CONSTANT =      2.611
MULTIPLE R SQUARE =     0.241
MULTIPLE R =     0.491
N.D.F.1 =    2
N.D.F.2 =        55
F FOR ANALYSIS OF VARIANCE ON R =        8.746
BETA WEIGHTS
  1.616  -1.244
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        0.701       0.884
   2   SQUAR      -0.460       0.778
SQUARED BETA WEIGHTS
  2.610   1.449
B WEIGHTS
 20.199 -13.869
INTERCEPT CONSTANT =     -0.852
MULTIPLE R SQUARE =     0.292
MULTIPLE R =    0.541
N.D.F.1 =    3
N.D.F.2 =        54
F FOR ANALYSIS OF VARIANCE ON R =       7.441
BETA WEIGHTS
  5.460  -9.934   5.016
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        2.370       0.803
   2   SQUAR      -3.796       0.706
   3   X CUBE      1.718       0.633
SQUARED BETA WEIGHTS
 29.815  98.687  25.158
B WEIGHTS
 68.252-113.948  63.029
INTERCEPT CONSTANT =     -7.572


ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =          0.188
 RESIDUAL S.S. =         0.812  DF =        56  RESIDUAL M.S. =        0.014
F FOR LINEAR FIT =    12.997

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.241
REDUCTION M.S. =         0.121
 RESIDUAL S.S. =         0.759  DF =        55  RESIDUAL M.S. =        0.014
F FOR QUADRATIC FIT =      8.746
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.053
F FOR QUADRATIC TERM ALONE =     3.836

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.292
REDUCTION M.S. =         0.097
 RESIDUAL S.S. =         0.708  DF =        54  RESIDUAL M.S. =        0.013
F FOR GENERAL CUBIC FIT =      7.441
   CTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,       0.051
   R CUBIC TERM ALONE =    3.908
```

RD RATING

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POLYNOMIAL FITTING FOR    2 VARIABLES-SRE AND TP SCORE-   139 OBSERVATIONS.

THE PREDICTOR VARIABLE(X) IS SRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1       X          0.342        0.358
 2     SQUAR        0.245        0.283
 3    X CUBE        0.182        0.232
 4       Y          2.806        1.504
CORRELATION MATRIX
 1       X          1.000        0.977        0.930       -0.168
 2     SQUAR        0.977        1.000        0.984       -0.110
 3    X CUBE        0.930        0.986        1.000       -0.053
 4       Y         -0.168       -0.110       -0.053        1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =      0.028
MULTIPLE R =     0.168
N.D.F.1 =    1
N.D.F.2 =          137
F FOR ANALYSIS OF VARIANCE ON R =        3.979
BETA WEIGHTS
 -0.168
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X          0.028      -1.000
SQUARED BETA WEIGHTS
  0.028
B WEIGHTS
 -0.733
INTERCEPT CONSTANT =       3.057
MULTIPLE R SQUARE =      0.093
MULTIPLE R =     0.305
N.D.F.1 =    2
N.D.F.2 =          136
F FOR ANALYSIS OF VARIANCE ON R =        6.961
BETA WEIGHTS
 -1.326    1.185
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X          0.223      -0.551
   2     SQUAR       -0.130      -0.360
SQUARED BETA WEIGHTS
  1.758    1.405
B WEIGHTS
 -5.788    6.559
INTERCEPT CONSTANT =       3.182
MULTIPLE R SQUARE =      0.131
MULTIPLE R =     0.362
N.D.F.1 =    3
N.D.F.2 =          135
F FOR ANALYSIS OF VARIANCE ON R =        6.801
BETA WEIGHTS
  1.065   -4.436    3.332
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X         -0.179      -0.494
   2     SQUAR        0.486      -0.302
   3    X CUBE       -0.176      -0.146
SQUARED BETA WEIGHTS
  1.133   19.677   11.102
B WEIGHTS
  4.647  -24.544   22.430
INTERCEPT CONSTANT =       3.138

ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.028
 RESIDUAL S.S. =         0.972  DF =      137  RESIDUAL M.S. =        0.007
F FOR LINEAR FIT =      3.979

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.093
REDUCTION M.S. =         0.046
 RESIDUAL S.S. =         0.907  DF =      136  RESIDUAL M.S. =        0.007
F FOR QUADRATIC FIT =      6.961
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.065
F FOR QUADRATIC TERM ALONE =      9.690

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.131
REDUCTION M.S. =         0.044
 RESIDUAL S.S. =         0.869  DF =      135  RESIDUAL M.S. =        0.006
F FOR GENERAL CUBIC FIT =      6.801
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,       0.038
F FOR CUBIC TERM ALONE =     5.972
```

RD RATING

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POLYNOMIAL FITTING FOR    2 VARIABLES-PRE AND TR SCORE.   139 OBSERVATIONS.

THE PREDICTOR VARIABLE(X) IS PRE, AND THE CRITERION VARIABLE(Y) IS TR SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.475      0.473
 2   SQUAR         0.447      0.456
 3   X CUBE        0.425      0.444
 4      Y          2.806      1.564
CORRELATION MATRIX
 1      X          1.000      0.994      0.982     -0.215
 2   SQUAR         0.994      1.000      0.997     -0.213
 3   X CUBE        0.982      0.997      1.000     -0.208
 4      Y         -0.215     -0.213     -0.208      1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.046
MULTIPLE R =     0.215
N.D.F.1 =   1
N.D.F.2 =        137
F FOR ANALYSIS OF VARIANCE ON R =       6.612
BETA WEIGHTS
 -0.215
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X          0.046     -1.000
SQUARED BETA WEIGHTS
  0.046
B WEIGHTS
 -0.710
INTERCEPT CONSTANT =      3.143
MULTIPLE R SQUARE =     0.046
MULTIPLE R =     0.215
N.D.F.1 =   2
N.D.F.2 =        136
F FOR ANALYSIS OF VARIANCE ON R =       3.282
BETA WEIGHTS
 -0.204  -0.010
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X          0.044     -1.000
   2    SQUAR         0.002     -0.994
SQUARED BETA WEIGHTS
  0.042   0.000
B WEIGHTS
 -0.676  -0.036
INTERCEPT CONSTANT =      3.143
MULTIPLE R SQUARE =     0.093
MULTIPLE R =     0.304
N.D.F.1 =   3
N.D.F.2 =        135
F FOR ANALYSIS OF VARIANCE ON R =       4.592
BETA WEIGHTS
 10.549 -25.903  15.252
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X         -2.263     -0.705
   2    SQUAR         5.527     -0.701
   3    X CUBE       -3.171     -0.683
SQUARED BETA WEIGHTS
111.283 670.951 232.638
B WEIGHTS
 34.915 -88.858  53.730
INTERCEPT CONSTANT =      3.132

 ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =       0.046
 RESIDUAL S.S. =        0.954  DF =       137  RESIDUAL M.S. =       0.007
F FOR LINEAR FIT =      6.612

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =       0.046
REDUCTION M.S. =        0.023
 RESIDUAL S.S. =        0.954  DF =       136  RESIDUAL M.S. =       0.007
F FOR QUADRATIC FIT =      3.282
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =       0.000
F FOR QUADRATIC TERM ALONE =     0.000

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =       0.093
REDUCTION M.S. =        0.031
 RESIDUAL S.S. =        0.907  DF =       135  RESIDUAL M.S. =       0.007
F FOR GENERAL CUBIC FIT =     4.592
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =       0.047
F FOR CUBIC TERM ALONE =    6.926
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RD RATING

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POLYNOMIAL FITTING FOR    2 VARIABLES-GRE AND TP SCORE.   139 OBSERVATIONS.

THE PREDICTOR VARIABLE(X) IS GRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1      X           0.969       0.054
 2    SQUAR         0.943       0.091
 3    X CUBE        0.919       0.119
 4      Y           2.806       1.504
CORRELATION MATRIX
 1      X           1.000       0.992       0.972       0.021
 2    SQUAR         0.992       1.000       0.994       0.006
 3    X CUBE        0.972       0.994       1.000      -0.005
 4      Y           0.021       0.006      -0.005       1.000
********************************************************************************
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
********************************************************************************
MULTIPLE R SQUARE =     0.000
MULTIPLE R =     0.021
N.O.F.1 =    1
N.O.F.2 =          137
F FOR ANALYSIS OF VARIANCE ON R =         0.060
BETA WEIGHTS
  0.021
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X          0.000       1.000
SQUARED BETA WEIGHTS
  0.000
B WEIGHTS
  0.603
INTERCEPT CONSTANT =      2.222
********************************************************************************
MULTIPLE R SQUARE =     0.013
MULTIPLE R =     0.113
N.O.F.1 =    2
N.O.F.2 =          136
F FOR ANALYSIS OF VARIANCE ON R =         0.873
BETA WEIGHTS
  0.871  -0.857
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X          0.018       0.185
   2    SQUAR       -0.006       0.057
SQUARED BETA WEIGHTS
  0.759   0.735
B WEIGHTS
 25.145 -14.818
INTERCEPT CONSTANT =     -7.602
********************************************************************************
MULTIPLE R SQUARE =     0.047
MULTIPLE R =     0.217
N.O.F.1 =    3
N.O.F.2 =          135
F FOR ANALYSIS OF VARIANCE ON R =        2.218
BETA WEIGHTS
 39.917 -85.574  46.272
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X          0.833       0.096
   2    SQUAR       -0.550       0.030
   3    X CUBE      -0.236      -0.024
SQUARED BETA WEIGHTS
593.4047322.9862141.134
B WEIGHTS
152.251********* 610.244
INTERCEPT CONSTANT =  -280.674


 ANOVA TABLE FOR POLYNOMIALS
********************************************************************************
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.000
 RESIDUAL S.S. =       1.000   DF =      137  RESIDUAL M.S. =        0.007
F FOR LINEAR FIT =     0.060
********************************************************************************

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.013
REDUCTION M.S. =       0.006
 RESIDUAL S.S. =       0.987   DF =      136  RESIDUAL M.S. =        0.007
F FOR QUADRATIC FIT =     0.873
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.012
F FOR QUADRATIC TERM ALONE =      1.686
********************************************************************************

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.047
REDUCTION M.S. =       0.016
 RESIDUAL S.S. =       0.953   DF =      135  RESIDUAL M.S. =        0.007

F FOR GENERAL CUBIC FIT =     2.218
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =        0.034
F FOR CUBIC TERM ALONE =     4.858
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POLYNOMIAL FITTING FOR    2 VARIABLES-WRE AND TP SCORE-   139 OBSERVATIONS.
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RD RATING

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THE PREDICTOR VARIABLE(X) IS WRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.


TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.617        0.183
 2    SQUAR        0.414        0.227
 3    X CUBE       0.296        0.232
 4      Y          2.806        1.564
CORRELATION MATRIX
 1      X          1.000        0.983        0.949        -0.051
 2    SQUAR        0.983        1.000        0.990        -0.075
 3    X CUBE       0.949        0.990        1.000        -0.085
 4      Y         -0.051       -0.075       -0.085         1.000
========================================================================
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
========================================================================
MULTIPLE R SQUARE =     0.003
MULTIPLE R =     0.051
N.D.F.1 =    1
N.D.F.2 =          137
F FOR ANALYSIS OF VARIANCE ON R =        0.362
BETA WEIGHTS
 -0.051
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X          0.003      -1.000
SQUARED BETA WEIGHTS
  0.003
B WEIGHTS
 -0.438
INTERCEPT CONSTANT =      3.076
========================================================================
MULTIPLE R SQUARE =     0.021
MULTIPLE R =     0.145
N.D.F.1 =    2
N.D.F.2 =          136
F FOR ANALYSIS OF VARIANCE ON R =        1.457
BETA WEIGHTS
  0.669  -0.713
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X          -0.034     -0.354
   2   SQUAR          0.055     -0.521
SQUARED BETA WEIGHTS
  0.448   0.538
B WEIGHTS
  5.715  -5.844
INTERCEPT CONSTANT =      1.368
========================================================================
MULTIPLE R SQUARE =     0.041
MULTIPLE R =     0.204
N.D.F.1 =    3
N.D.F.2 =          135
F FOR ANALYSIS OF VARIANCE ON R =        1.946
BETA WEIGHTS
  3.072  -6.399   3.337
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X          -0.158     -0.252
   2   SQUAR          0.483     -0.371
   3   X CUBE        -0.284     -0.418
SQUARED BETA WEIGHTS
  9.439  40.947  11.134
B WEIGHTS
 26.233 -44.017  22.482
INTERCEPT CONSTANT =     -1.814



 ANOVA TABLE FOR POLYNOMIALS
========================================================================
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.003
 RESIDUAL S.S. =        0.997  DF =       137  RESIDUAL M.S. =        0.007
F FOR LINEAR FIT =      0.362
========================================================================

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.021
REDUCTION M.S. =        0.010
 RESIDUAL S.S. =        0.979  DF =       136  RESIDUAL M.S. =        0.007
F FOR QUADRATIC FIT =      1.457
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.018
F FOR QUADRATIC TERM ALONE =     2.548
========================================================================

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.041
REDUCTION M.S. =        0.014
 RESIDUAL S.S. =        0.959  DF =       135  RESIDUAL M.S. =        0.007
```



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  FOR GENERAL CUBIC FIT =      1.946
 DUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,      0.020
 FOR CUBIC TERM ALONE =     2.883
========================================================================
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POLYNOMIAL FITTING FOR    2 VARIABLES-SHE AND TP SCORE-   137 OBSERVATIONS.
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RM RATING

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THE PREDICTOR VARIABLE(X) IS SHE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1      X             0.628        0.331
 2    SQUAR           0.503        0.348
 3    X CUBE          0.426        0.356
 4      Y             4.453        1.925
CORRELATION MATRIX
 1      X             1.000        0.960        0.907        0.211
 2    SQUAR           0.960        1.000        0.988        0.234
 3    X CUBE          0.907        0.988        1.000        0.244
 4      Y             0.211        0.234        0.244        1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.044
MULTIPLE R =     0.211
N.D.F.1 =    1
N.D.F.2 =          135
F FOR ANALYSIS OF VARIANCE ON R =          6.285
BETA WEIGHTS
  0.211
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X          0.044        1.000
SQUARED BETA WEIGHTS
  0.044
B WEIGHTS
  1.228
INTERCEPT CONSTANT =       3.681
MULTIPLE R SQUARE =      0.057
MULTIPLE R =     0.238
N.D.F.1 =    2
N.D.F.2 =          134
F FOR ANALYSIS OF VARIANCE ON R =          4.034
BETA WEIGHTS
 -0.168    0.394
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X          -0.035       0.885
   2    SQUAR          0.092       0.980
SQUARED BETA WEIGHTS
  0.028    0.156
B WEIGHTS
 -0.976    2.181
INTERCEPT CONSTANT =       3.968
MULTIPLE R SQUARE =     0.068
MULTIPLE R =     0.260
N.D.F.1 =    3
N.D.F.2 =          133
F FOR ANALYSIS OF VARIANCE ON R =          3.218
BETA WEIGHTS
  0.746  -2.231    1.770
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1       X           0.157       0.811
   2    SQUAR         -0.521       0.898
   3    X CUBE         0.431       0.937
SQUARED BETA WEIGHTS
  0.557    4.976    3.133
B WEIGHTS
  4.346 -12.317    9.567
INTERCEPT CONSTANT =       3.857

ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.044
 RESIDUAL S.S. =        0.956   DF =      135   RESIDUAL M.S. =        0.007
F FOR LINEAR FIT =      6.285

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =       0.057
REDUCTION M.S. =        0.028
 RESIDUAL S.S. =        0.943   DF =      134   RESIDUAL M.S. =        0.007
F FOR QUADRATIC FIT =      4.034
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.012
F FOR QUADRATIC TERM ALONE =      1.748

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.048
REDUCTION M.S. =        0.023
 RESIDUAL S.S. =        0.932   DF =      133   RESIDUAL M.S. =        0.007
 FOR GENERAL CUBIC FIT =      3.218
 EDUCTION DUE TO CUBIC TERM ALONE WITH 1 OF 3 ,       0.011
 FOR CUBIC TERM ALONE =      1.554
```

RM RATING

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POLYNOMIAL FITTING FOR    2 VARIABLES-PHE AND TP SCORE-   137 OBSERVATIONS.

THE PREDICTOR VARIABLE(X) IS PHE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.800       0.341
 2   SQUAR         0.756       0.342
 3   X CUBE        0.719       0.348
 4      Y          4.453       1.925
CORRELATION MATRIX
 1      X          1.000       0.985       0.953       0.156
 2   SQUAR         0.985       1.000       0.991       0.164
 3   X CUBE        0.953       0.991       1.000       0.167
 4      Y          0.156       0.164       0.167       1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.024
MULTIPLE R =     0.156
N.D.F.1 =    1
N.D.F.2 =         135
F FOR ANALYSIS OF VARIANCE ON R =        3.387
BETA WEIGHTS
  0.156
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        0.024       1.000
SQUARED BETA WEIGHTS
  0.024
B WEIGHTS
  0.882
INTERCEPT CONSTANT =      3.747
MULTIPLE R SQUARE =     0.028
MULTIPLE R =     0.166
N.D.F.1 =    2
N.D.F.2 =         134
F FOR ANALYSIS OF VARIANCE ON R =        1.902
BETA WEIGHTS
 -0.159   0.320
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X       -0.025       0.942
   2   SQUAR       0.052       0.986
SQUARED BETA WEIGHTS
  0.025   0.102
B WEIGHTS
 -0.894   1.801
INTERCEPT CONSTANT =      3.807
MULTIPLE R SQUARE =     0.031
MULTIPLE R =     0.177
N.D.F.1 =    3
N.D.F.2 =         133
F FOR ANALYSIS OF VARIANCE ON R =        1.428
BETA WEIGHTS
  1.852  -4.346   2.710
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        0.290       0.886
   2   SQUAR      -0.712       0.927
   3   X CUBE      0.453       0.947
SQUARED BETA WEIGHTS
  3.430  18.890   7.345
B WEIGHTS
 10.440 -24.658  15.010
INTERCEPT CONSTANT =      3.795

ANOVA TABLE FOR POLYNOMIALS
REDUCTION DUE TO LINEAR FIT, WITH 1 DF =         0.024
RESIDUAL S.S. =        0.976   DF =      135   RESIDUAL M.S. =       0.007
F FOR LINEAR FIT =      3.387

REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.028
REDUCTION M.S. =       0.014
RESIDUAL S.S. =        0.972   DF =      134   RESIDUAL M.S. =       0.007
F FOR QUADRATIC FIT =      1.902
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.003
F FOR QUADRATIC TERM ALONE =     0.432

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.031
REDUCTION M.S. =       0.010
RESIDUAL S.S. =        0.969   DF =      133   RESIDUAL M.S. =       0.007
F FOR GENERAL CUBIC FIT =      1.428
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,      0.004
F FOR CUBIC TERM ALONE =     0.493
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POLYNOMIAL FITTING FOR    2 VARIABLES-GRE AND TP SCORE.   137 OBSERVATIONS.
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RM RATING

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THE PREDICTOR VARIABLE(X) IS GRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.997        0.007
 2   SQUAR         0.995        0.013
 3   X CUBE        0.992        0.019
 4      Y          4.453        1.925
CORRELATION MATRIX
 1      X          1.000        1.000        1.000        0.041
 2   SQUAR         1.000        1.000        1.000        0.044
 3   X CUBE        1.000        1.000        1.000        0.046
 4      Y          0.041        0.044        0.046        1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =    0.002
MULTIPLE R =    0.041
N.D.F.1 =   1
N.D.F.2 =        135
F FOR ANALYSIS OF VARIANCE ON R =      0.227
BETA WEIGHTS
  0.041
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        0.002       1.000
SQUARED BETA WEIGHTS
  0.002
B WEIGHTS
 12.035
INTERCEPT CONSTANT =     -7.551
MULTIPLE R SQUARE =    0.140
MULTIPLE R =    0.374
N.D.F.1 =   2
N.D.F.2 =        134
F FOR ANALYSIS OF VARIANCE ON R =     10.869
BETA WEIGHTS
-51.053  51.095
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X       -2.092       0.110
   2   SQUAR       2.231       0.117
SQUARED BETA WEIGHTS
606.3682619.691
B WEIGHTS
*****997644.570
INTERCEPT CONSTANT =  7356.344
MULTIPLE R SQUARE =    0.139
MULTIPLE R =    0.372
N.D.F.1 =   3
N.D.F.2 =        133
F FOR ANALYSIS OF VARIANCE ON R =      7.131
BETA WEIGHTS
-35.047  19.528  15.563
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X       -1.436       0.110
   2   SQUAR       0.853       0.117
   3   X CUBE      0.722       0.125
SQUARED BETA WEIGHTS
278.327 381.346 242.193
B WEIGHTS
*******2921.6971980.930
INTERCEPT CONSTANT =  5796.982


ANOVA TABLE FOR POLYNOMIALS
REDUCTION DUE TO LINEAR FIT, WITH 1 DF =      0.002
RESIDUAL S.S. =        0.998   DF =      135   RESIDUAL M.S. =      0.007
F FOR LINEAR FIT =     0.227

REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =      0.140
REDUCTION M.S. =       0.070
RESIDUAL S.S. =        0.860   DF =      134   RESIDUAL M.S. =      0.006
F FOR QUADRATIC FIT =   10.869
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =      0.138
F FOR QUADRATIC TERM ALONE =   21.476

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =      0.139
REDUCTION M.S. =       0.046
RESIDUAL S.S. =        0.861   DF =      133   RESIDUAL M.S. =      0.006
F FOR GENERAL CUBIC FIT =     7.131
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,    -0.001
F FOR CUBIC TERM ALONE =  -0.156
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POLYNOMIAL FITTING FOR    2 VARIABLES-WRE AND TP SCORE-   137 OBSERVATIONS.
```

RM RATING

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THE PREDICTOR VARIABLE(X) IS WRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.632       0.232
 2   SQUAR         0.453       0.252
 3   X CUBE        0.342       0.253
 4      Y          4.453       1.925
CORRELATION MATRIX
 1      X          1.000       0.956       0.898       0.366
 2   SQUAR         0.956       1.000       0.985       0.390
 3   X CUBE        0.898       0.985       1.000       0.387
 4      Y          0.366       0.390       0.387       1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.134
MULTIPLE R =    0.366
N.D.F.1 =   1
N.D.F.2 =         135
F FOR ANALYSIS OF VARIANCE ON R =      20.845
BETA WEIGHTS
  0.366
CONTRIBUTIONS TO MULTIPLE CORRELATION
  AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        0.134      1.000
SQUARED BETA WEIGHTS
  0.134
B WEIGHTS
  3.037
INTERCEPT CONSTANT =     2.533
MULTIPLE R SQUARE =     0.153
MULTIPLE R =    0.391
N.D.F.1 =   2
N.D.F.2 =         134
F FOR ANALYSIS OF VARIANCE ON R =      12.103
BETA WEIGHTS
 -0.089   0.475
CONTRIBUTIONS TO MULTIPLE CORRELATION
  AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X       -0.033      0.935
   2   SQUAR       0.186      0.998
SQUARED BETA WEIGHTS
  0.008   0.226
B WEIGHTS
 -0.739   3.630
INTERCEPT CONSTANT =     3.276
MULTIPLE R SQUARE =     0.154
MULTIPLE R =    0.392
N.D.F.1 =   3
N.D.F.2 =         133
F FOR ANALYSIS OF VARIANCE ON R =      8.042
BETA WEIGHTS
 -0.260   0.959  -0.324
CONTRIBUTIONS TO MULTIPLE CORRELATION
  AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X       -0.095      0.933
   2   SQUAR       0.374      0.996
   3   X CUBE     -0.126      0.987
SQUARED BETA WEIGHTS
  0.068   0.919   0.105
B WEIGHTS
 -2.159   7.320  -2.472
INTERCEPT CONSTANT =     3.347


ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.134
 RESIDUAL S.S. =       0.866   DF =     135  RESIDUAL M.S. =       0.006
F FOR LINEAR FIT =    20.845

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.153
REDUCTION M.S. =       0.077
 RESIDUAL S.S. =       0.847   DF =     134  RESIDUAL M.S. =       0.006
F FOR QUADRATIC FIT =    12.103
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.019
F FOR QUADRATIC TERM ALONE =     3.046

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =       0.154
REDUCTION M.S. =       0.051
 RESIDUAL S.S. =       0.846   DF =     133  RESIDUAL M.S. =       0.006

 FOR GENERAL CUBIC FIT =     8.042
 DUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =       0.001
 FOR CUBIC TERM ALONE =   0.086
```

ST RATING

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********************************************************************************
POLYNOMIAL FITTING FOR    2 VARIABLES-SHE AND TP SCORE-   152 OBSERVATIONS,

THE PREDICTOR VARIABLE(X) IS SHE, AND THE CRITERION VARIABLE(Y) IS TP SCORE,

TEST MEANS AND STANDARD DEVIATIONS
 1      X         0.280       0.283
 2   SQUAR        0.158       0.250
 3   X CUBE       0.110       0.234
 4      Y         5.783       2.425
CORRELATION MATRIX
 1      X         1.000       0.938       0.858       0.199
 2   SQUAR        0.938       1.000       0.980       0.246
 3   X CUBE       0.858       0.980       1.000       0.259
 4      Y         0.199       0.246       0.259       1.000
********************************************************************************
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS,
********************************************************************************
MULTIPLE R SQUARE =     0.040
MULTIPLE R =    0.199
N.D.F.1 =    1
N.D.F.2 =          150
F FOR ANALYSIS OF VARIANCE ON R =        6.217
BETA WEIGHTS
  0.199
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X         0.040       1.000
SQUARED BETA WEIGHTS
  0.040
B WEIGHTS
  1.711
INTERCEPT CONSTANT =      5.304
********************************************************************************
MULTIPLE R SQUARE =     0.069
MULTIPLE R =    0.262
N.D.F.1 =    2
N.D.F.2 =          149
F FOR ANALYSIS OF VARIANCE ON R =        5.483
BETA WEIGHTS
 -0.258   0.488
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        -0.051       0.762
   2   SQUAR        0.120       0.990
SQUARED BETA WEIGHTS
  0.067   0.238
B WEIGHTS
 -2.213   4.724
INTERCEPT CONSTANT =      5.657
********************************************************************************
MULTIPLE R SQUARE =     0.069
MULTIPLE R =    0.263
N.D.F.1 =    3
N.D.F.2 =          148
F FOR ANALYSIS OF VARIANCE ON R =        3.656
BETA WEIGHTS
 -0.142   0.153   0.231
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        -0.028       0.799
   2   SQUAR        0.038       0.936
   3   X CUBE       0.060       0.985
SQUARED BETA WEIGHTS
  0.020   0.023   0.053
B WEIGHTS
 -1.218   1.403   2.398
INTERCEPT CONSTANT =      5.627

 ANOVA TABLE FOR POLYNOMIALS
********************************************************************************
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =          0.046
 RESIDUAL S.S. =      0.960   DF =      150   RESIDUAL M.S. =       0.006
F FOR LINEAR FIT =      6.217
********************************************************************************

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.069
REDUCTION M.S. =        0.034
 RESIDUAL S.S. =        0.931   DF =      149   RESIDUAL M.S. =       0.006
F FOR QUADRATIC FIT =      5.483
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =         0.029
F FOR QUADRATIC TERM ALONE =      4.600
********************************************************************************

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.069
REDUCTION M.S. =        0.023
RESIDUAL S.S. =         0.931   DF =      148   RESIDUAL M.S. =       0.006
F FOR GENERAL CUBIC FIT =      3.656
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =         0.000
F FOR CUBIC TERM ALONE =     0.071
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ST RATING

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==========================================================================
POLYNOMIAL FITTING FOR    2 VARIABLES-PRE AND TP SCORE-   152 OBSERVATIONS,


THE PREDICTOR VARIABLE(X) IS PRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.


TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.549        0.390
 2   SQUAR         0.452        0.363
 3   X CUBE        0.385        0.347
 4      Y          5.783        2.425
CORRELATION MATRIX
 1      X          1.000        0.972        0.923        0.058
 2   SQUAR         0.972        1.000        0.987        0.055
 3   X CUBE        0.923        0.987        1.000        0.065
 4      Y          0.058        0.055        0.065        1.000
==========================================================================
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
==========================================================================
MULTIPLE R SQUARE =     0.003
MULTIPLE R =     0.058
N.D.F.1 =     1
N.D.F.2 =          150
F FOR ANALYSIS OF VARIANCE ON R =        0.509
BETA WEIGHTS
  0.058
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1    X          0.003        1.000
SQUARED BETA WEIGHTS
  0.003
B WEIGHTS
  0.362
INTERCEPT CONSTANT =       5.584
==========================================================================
MULTIPLE R SQUARE =     0.003
MULTIPLE R =     0.058
N.D.F.1 =     2
N.D.F.2 =          149
F FOR ANALYSIS OF VARIANCE ON R =        0.255
BETA WEIGHTS
  0.083  -0.025
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        0.005        0.995
   2   SQUAR      -0.001        0.943
SQUARED BETA WEIGHTS
  0.007   0.001
B WEIGHTS
  0.51?  -0.170
INTERCEPT CONSTANT =       5.577
==========================================================================
MULTIPLE R SQUARE =     0.102
MULTIPLE R =     0.320
N.D.F.1 =     3
N.D.F.2 =          148
F FOR ANALYSIS OF VARIANCE ON R =        5.634
BETA WEIGHTS
  4.864 -11.756   7.177
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        0.283        0.182
   2   SQUAR      -0.648        0.172
   3   X CUBE      0.468        0.204
SQUARED BETA WEIGHTS
 23.659 138.208  51.513
B WEIGHTS
 30.272 -78.804  50.161
INTERCEPT CONSTANT =       5.410



 ANOVA TABLE FOR POLYNOMIALS
==========================================================================
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =          0.003
 RESIDUAL S.S. =         0.997  DF =       150  RESIDUAL M.S. =       0.007
F FOR LINEAR FIT =       0.509
==========================================================================

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.003
REDUCTION M.S. =         0.002
 RESIDUAL S.S. =         0.997  DF =       149  RESIDUAL M.S. =       0.007
F FOR QUADRATIC FIT =      0.259
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.000
F FOR QUADRATIC TERM ALONE =      0.005
==========================================================================

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.102
REDUCTION M.S. =         0.034
 RESIDUAL S.S. =         0.898  DF =       148  RESIDUAL M.S. =       0.006
      GENERAL CUBIC FIT =      5.634
      ION DUE TO CUBIC TERM ALONE WITH 1 DF = ,       0.099
      CUBIC TERM ALONE =  16.339
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POLYNOMIAL FITTING FOR    2 VARIABLES-GRE AND TP SCORE.   152 OBSERVATIONS.
```

ST RATING

```
THE PREDICTOR VARIABLE(X) IS GRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1        X           0.897        0.187
 2     SQUAR          0.840        0.203
 3     X CUBE         0.790        0.220
 4        Y           5.783        2.425
CORRELATION MATRIX
 1        X           1.000        0.969        0.914        0.099
 2     SQUAR          0.969        1.000        0.985        0.183
 3     X CUBE         0.914        0.985        1.000        0.243
 4        Y           0.099        0.183        0.243        1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.010
MULTIPLE R =     0.099
N.D.F.1 =     1
N.D.F.2 =          150
F FOR ANALYSIS OF VARIANCE ON R =      1.490
BETA WEIGHTS
  0.099
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1        X         0.010       1.000
SQUARED BETA WEIGHTS
  0.010
B WEIGHTS
  1.285
INTERCEPT CONSTANT =       4.630
MULTIPLE R SQUARE =     0.134
MULTIPLE R =     0.366
N.D.F.1 =    2
N.D.F.2 =          149
F FOR ANALYSIS OF VARIANCE ON R =      11.550
BETA WEIGHTS
 -1.294    1.437
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1        X         -0.128      0.271
   2     SQUAR         0.263      0.499
SQUARED BETA WEIGHTS
  1.674    2.066
B WEIGHTS
 -16.765  17.133
INTERCEPT CONSTANT =       6.437
MULTIPLE R SQUARE =     0.178
MULTIPLE R =     0.422
N.D.F.1 =     3
N.D.F.2 =          148
F FOR ANALYSIS OF VARIANCE ON R =      10.692
BETA WEIGHTS
  1.686  -5.777    4.392
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1        X          0.167      0.235
   2     SQUAR        -1.056      0.433
   3     X CUBE        1.067      0.575
SQUARED BETA WEIGHTS
  2.843  33.374  19.288
B WEIGHTS
 21.849 -68.886  48.351
INTERCEPT CONSTANT =       5.825


ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.010
 RESIDUAL S.S. =         0.990   DF =      150  RESIDUAL M.S. =        0.007
F FOR LINEAR FIT =      1.490

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.134
REDUCTION M.S. =        0.067
 RESIDUAL S.S. =        0.866   DF =      149  RESIDUAL M.S. =        0.006
F FOR QUADRATIC FIT =    11.550
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =       0.124
F FOR QUADRATIC TERM ALONE =    21.408

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =       0.178
REDUCTION M.S. =        0.059
 RESIDUAL S.S. =        0.822   DF =      148  RESIDUAL M.S. =        0.006
F FOR GENERAL CUBIC FIT =     10.692
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =         0.044
F FOR CUBIC TERM ALONE =     7.904
```

ST RATING

```
POLYNOMIAL FITTING FOR    2 VARIABLES-WRE AND TP SCORE.   152 OBSERVATIONS.

THE PREDICTOR VARIABLE(X) IS WRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.

TEST MEANS AND STANDARD DEVIATIONS
 1      X           0.603        0.207
 2   SQUAR          0.406        0.237
 3   X CUBE         0.292        0.236
 4      Y           5.783        2.425
CORRELATION MATRIX
 1      X           1.000        0.973        0.921        0.234
 2   SQUAR          0.973        1.000        0.985        0.265
 3   X CUBE         0.921        0.985        1.000        0.263
 4      Y           0.234        0.265        0.263        1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.055
MULTIPLE R =     0.234
N.D.F.1 =     1
N.D.F.2 =          150
F FOR ANALYSIS OF VARIANCE ON R =        8.707
BETA WEIGHTS
  0.234
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X         0.055        1.000
SQUARED BETA WEIGHTS
  0.055
B WEIGHTS
  2.746
INTERCEPT CONSTANT =      4.128
MULTIPLE R SQUARE =     0.080
MULTIPLE R =     0.283
N.D.F.1 =     2
N.D.F.2 =          149
F FOR ANALYSIS OF VARIANCE ON R =        6.467
BETA WEIGHTS
 -0.426   0.679
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        -0.100        0.829
   2    SQUAR       0.180        0.936
SQUARED BETA WEIGHTS
  0.182   0.461
B WEIGHTS
 -4.999   6.937
INTERCEPT CONSTANT =      5.982
MULTIPLE R SQUARE =     0.123
MULTIPLE R =     0.351
N.D.F.1 =     3
N.D.F.2 =          148
F FOR ANALYSIS OF VARIANCE ON R =        6.925
BETA WEIGHTS
 -2.679   6.135  -3.314
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS,  2ND COLUMN)
   1      X        -0.628        0.698
   2    SQUAR       1.624        0.754
   3    X CUBE     -0.873        0.751
SQUARED BETA WEIGHTS
  7.179  37.644  10.980
B WEIGHTS
-31.415  62.653 -34.060
INTERCEPT CONSTANT =      9.241

 ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.055
 RESIDUAL S.S. =        0.945  DF =      150   RESIDUAL M.S. =       0.006
F FOR LINEAR FIT =      8.707

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.080
REDUCTION M.S. =        0.040
 RESIDUAL S.S. =        0.920  DF =      149  RESIDUAL M.S. =       0.006
F FOR QUADRATIC FIT =      6.467
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =       0.025
F FOR QUADRATIC TERM ALONE =     4.050

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =       0.123
REDUCTION M.S. =        0.041
 RESIDUAL S.S. =        0.877  DF =      148  RESIDUAL M.S. =       0.006
 F FOR GENERAL CUBIC FIT =     6.925
REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF =        0.043
 F FOR CUBIC TERM ALONE =    7.296
```

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POLYNOMIAL FITTING FOR    2 VARIABLES-SRE AND TP SCORE-    3? OBSERVATIONS.
```

TM RATING

```
THE PREDICTOR VARIABLE(X) IS SRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.


TEST MEANS AND STANDARD DEVIATIONS
 1      X           0.173       0.194
 2   SQUAR          0.067       0.135
 3   X CUBE         0.035       0.109
 4      Y           5.282       1.986
CORRELATION MATRIX
 1      X           1.000       0.905       0.791       0.198
 2   SQUAR          0.905       1.000       0.972       0.052
 3   X CUBE         0.791       0.972       1.000      -0.057
 4      Y           0.198       0.052      -0.057       1.000
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
MULTIPLE R SQUARE =     0.039
MULTIPLE R =     0.198
N.D.F.1 =   1
N.D.F.2 =          37
F FOR ANALYSIS OF VARIANCE ON R =       1.503
BETA WEIGHTS
  0.198
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS.  2ND COLUMN)
   1      X           0.039       1.000
SQUARED BETA WEIGHTS
  0.039
B WEIGHTS
  2.024
INTERCEPT CONSTANT =       4.932
MULTIPLE R SQUARE =     0.129
MULTIPLE R =     0.359
N.D.F.1 =   2
N.D.F.2 =          36
F FOR ANALYSIS OF VARIANCE ON R =       2.656
BETA WEIGHTS
  0.835  -0.704
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS.  2ND COLUMN)
   1      X           0.165       0.591
   2   SQUAR         -0.036       0.144
SQUARED BETA WEIGHTS
  0.698   0.496
B WEIGHTS
  8.558 -10.348
INTERCEPT CONSTANT =       4.490
MULTIPLE R SQUARE =     0.217
MULTIPLE R =     0.466
N.D.F.1 =   3
N.D.F.2 =          35
F FOR ANALYSIS OF VARIANCE ON R =       3.230
BETA WEIGHTS
 -0.463   3.047  -2.651
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS.  2ND COLUMN)
   1      X          -0.092       0.424
   2   SQUAR          0.158       0.111
   3   X CUBE         0.151      -0.122
SQUARED BETA WEIGHTS
  0.215   9.285   7.028
B WEIGHTS
 -4.749  44.744 -48.424
INTERCEPT CONSTANT =       4.802


 ANOVA TABLE FOR POLYNOMIALS
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =         0.039
 RESIDUAL S.S. =         0.961   DF =      37   RESIDUAL M.S. =        0.026
F FOR LINEAR FIT =       1.503

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =          0.129
REDUCTION M.S. =         0.064
 RESIDUAL S.S. =         0.871   DF =       36   RESIDUAL M.S. =        0.024
F FOR QUADRATIC FIT =       2.656
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.090
F FOR QUADRATIC TERM ALONE =       3.709

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.217
REDUCTION M.S. =         0.072
 RESIDUAL S.S. =         0.783   DF =       35   RESIDUAL M.S. =        0.022
 FOR GENERAL CUBIC FIT =       3.230
 UCTION DUE TO CUBIC TERM ALONE WITH 1 DF =          0.088
 OR CUBIC TERM ALONE =     3.944
```

TM RATING

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==========================================================================
POLYNOMIAL FITTING FOR    2 VARIABLES-PRE AND TP SCORE-    39 OBSERVATIONS.


THE PREDICTOR VARIABLE(X) IS PRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.


TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.450       0.354
 2    SQUAR        0.325       0.296
 3   X CUBE        0.245       0.256
 4      Y          5.282       1.986
CORRELATION MATRIX
 1      X          1.000       0.971       0.911       0.243
 2    SQUAR        0.971       1.000       0.982       0.281
 3   X CUBE        0.911       0.982       1.000       0.280
 4      Y          0.243       0.281       0.280       1.000
==========================================================================
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
==========================================================================
MULTIPLE R SQUARE =     0.059
MULTIPLE R =    0.243
N.D.F.1 =   1
N.D.F.2 =          37
F FOR ANALYSIS OF VARIANCE ON R =        2.329
BETA WEIGHTS
  0.243
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
   1      X          0.059       1.000
SQUARED BETA WEIGHTS
  0.059
B WEIGHTS
  1.366
INTERCEPT CONSTANT =       4.667
==========================================================================
MULTIPLE R SQUARE =     0.094
MULTIPLE R =    0.306
N.D.F.1 =   2
N.D.F.2 =          36
F FOR ANALYSIS OF VARIANCE ON R =        1.857
BETA WEIGHTS
 -0.502   0.748
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
   1      X         -0.122       0.796
   2    SQUAR        0.216       0.918
SQUARED BETA WEIGHTS
  0.252   0.591
B WEIGHTS
 -2.821   5.154
INTERCEPT CONSTANT =       4.879
==========================================================================
MULTIPLE R SQUARE =     0.153
MULTIPLE R =    0.391
N.D.F.1 =   3
N.D.F.2 =          35
F FOR ANALYSIS OF VARIANCE ON R =        2.112
BETA WEIGHTS
 -3.083   6.7=6  -3.575
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
   1      X         -0.750       0.622
   2    SQUAR        1.906       0.717
   3   X CUBE       -1.002       0.716
SQUARED BETA WEIGHTS
  9.506  46.044  12.784
B WEIGHTS
-17.309  45.508 -27.737
INTERCEPT CONSTANT =       5.103


 ANOVA TABLE FOR POLYNOMIALS
==========================================================================
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =        0.059
 RESIDUAL S.S. =        0.941  DF =        37  RESIDUAL M.S. =        0.025
F FOR LINEAR FIT =     2.329
==========================================================================

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.094
REDUCTION M.S. =        0.047
 RESIDUAL S.S. =        0.906  DF =        36  RESIDUAL M.S. =        0.025
F FOR QUADRATIC FIT =      1.857
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.034
F FOR QUADRATIC TERM ALONE =      1.363
==========================================================================

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.153
REDUCTION M.S. =        0.051
 RESIDUAL S.S. =        0.847  DF =        35  RESIDUAL M.S. =        0.024
  R GENERAL CUBIC FIT =      2.112
  CTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,       0.060
  R CUBIC TERM ALONE =     2.470
==========================================================================
```

TM RATING

```
****************************************************************************
POLYNOMIAL FITTING FOR    2 VARIABLES-GRE AND TP SCORE-    37 OBSERVATIONS.


THE PREDICTOR VARIABLE(X) IS GRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.


TEST MEANS AND STANDARD DEVIATIONS
 1       X          0.871        0.173
 2    SQUAR         0.788        0.210
 3    X CUBE        0.720        0.245
 4       Y          5.282        1.946
CORRELATION MATRIX
 1       X          1.000        0.952        0.888        0.186
 2    SQUAR         0.952        1.000        0.986        0.170
 3    X CUBE        0.888        0.986        1.000        0.163
 4       Y          0.186        0.170        0.163        1.000
****************************************************************************
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
****************************************************************************
MULTIPLE R SQUARE =     0.035
MULTIPLE R =     0.186
N.D.F.1 =    1
N.D.F.2 =         37
F FOR ANALYSIS OF VARIANCE ON R =        1.327
BETA WEIGHTS
  0.186
CONTRIBUTIONS TO MULTIPLE CORRELATION
    AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
    1     X           0.035        1.000
SQUARED BETA WEIGHTS
  0.035
B WEIGHTS
  2.131
INTERCEPT CONSTANT =      3.426
****************************************************************************
MULTIPLE R SQUARE =     0.035
MULTIPLE R =     0.187
N.D.F.1 =    2
N.D.F.2 =         36
F FOR ANALYSIS OF VARIANCE ON R =        0.656
BETA WEIGHTS
  0.257   -0.075
CONTRIBUTIONS TO MULTIPLE CORRELATION
    AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
    1     X           0.048        0.993
    2   SQUAR        -0.013        0.907
SQUARED BETA WEIGHTS
  0.066   0.006
B WEIGHTS
  2.944   -0.744
INTERCEPT CONSTANT =      3.272
****************************************************************************
MULTIPLE R SQUARE =     0.085
MULTIPLE R =     0.291
N.D.F.1 =    3
N.D.F.2 =         35
F FOR ANALYSIS OF VARIANCE ON R =        1.082
BETA WEIGHTS
  3.436   -8.987   5.971
CONTRIBUTIONS TO MULTIPLE CORRELATION
    AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
    1     X           0.639        0.639
    2   SQUAR        -1.529        0.584
    3   X CUBE        0.974        0.560
SQUARED BETA WEIGHTS
 11.807  80.768  35.655
B WEIGHTS
 39.356 -84.877  48.463
INTERCEPT CONSTANT =      2.981



 ANOVA TABLE FOR POLYNOMIALS
****************************************************************************
 REDUCTION DUE TO LINEAR FIT, WITH 1 DF =          0.035
 RESIDUAL S.S. =         0.965  DF =        37  RESIDUAL M.S. =        0.026
F FOR LINEAR FIT =      1.327
****************************************************************************

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =        0.035
REDUCTION M.S. =        0.018
 RESIDUAL S.S. =        0.965  DF =        36  RESIDUAL M.S. =        0.027
F FOR QUADRATIC FIT =      0.656
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 DF, =        0.001
F FOR QUADRATIC TERM ALONE =      0.020
****************************************************************************

REDUCTION DUE TO GENERAL CUBIC FIT WITH DF 3, =        0.085
REDUCTION M.S. =        0.028
 RESIDUAL S.S. =        0.915  DF =        35  RESIDUAL M.S. =        0.026

 F FOR GENERAL CUBIC FIT =      1.082
 REDUCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,       0.050
 F FOR CUBIC TERM ALONE =     1.903
****************************************************************************
```

TM RATING

```
==========================================================================
POLYNOMIAL FITTING FOR    2 VARIABLES-WRE AND TP SCORE-    39 OBSERVATIONS.


THE PREDICTOR VARIABLE(X) IS WRE, AND THE CRITERION VARIABLE(Y) IS TP SCORE.


TEST MEANS AND STANDARD DEVIATIONS
 1      X          0.496      0.194
 2   SQUAR         0.283      0.193
 3   X CUBE        0.176      0.165
 4      Y          5.282      1.986
CORRELATION MATRIX
 1      X          1.000      0.978      0.930      0.403
 2   SQUAR         0.978      1.000      0.986      0.419
 3   X CUBE        0.930      0.986      1.000      0.407
 4      Y          0.403      0.419      0.409      1.000
==========================================================================
FIRST, SECOND, AND THIRD DEGREE POLYNOMIALS.
==========================================================================
MULTIPLE R SQUARE =     0.162
MULTIPLE R =    0.403
N.D.F.1 =    1
N.D.F.2 =          37
F FOR ANALYSIS OF VARIANCE ON R =       7.172
BETA WEIGHTS
  0.403
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
   1      X        0.162      1.000
SQUARED BETA WEIGHTS
  0.162
B WEIGHTS
  4.127
INTERCEPT CONSTANT =      3.234
==========================================================================
MULTIPLE R SQUARE =     0.177
MULTIPLE R =    0.421
N.D.F.1 =    2
N.D.F.2 =          36
F FOR ANALYSIS OF VARIANCE ON R =       3.867
BETA WEIGHTS
 -0.161   0.576
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
   1      X       -0.065      0.958
   2   SQUAR       0.242      0.997
SQUARED BETA WEIGHTS
  0.026   0.332
B WEIGHTS
 -1.444   5.918
INTERCEPT CONSTANT =      4.424
==========================================================================
MULTIPLE R SQUARE =     0.224
MULTIPLE R =    0.473
N.D.F.1 =    3
N.D.F.2 =          35
F FOR ANALYSIS OF VARIANCE ON R =       3.362
BETA WEIGHTS
 -3.771   8.708  -4.667
CONTRIBUTIONS TO MULTIPLE CORRELATION
   AND REGRESSION FACTOR LOADINGS, 2ND COLUMN)
   1      X       -1.520      0.852
   2   SQUAR       3.650      0.886
   3   X CUBE     -1.907      0.864
SQUARED BETA WEIGHTS
 14.222  75.833  21.785
B WEIGHTS
-38.622  89.446 -56.064
INTERCEPT CONSTANT =      9.017


 ANOVA TABLE FOR POLYNOMIALS
==========================================================================
 REDUCTION DUE TO LINEAR FIT, WITH 1 OF =        0.162
 RESIDUAL S.S. =        0.838  DF =       37  RESIDUAL M.S. =       0.023
F FOR LINEAR FIT =     7.172
==========================================================================

 REDUCTION DUE TO GENERAL QUADRATIC FIT WITH DF 2, =       0.177
REDUCTION M.S. =        0.088
 RESIDUAL S.S. =        0.823  DF =       36  RESIDUAL M.S. =       0.023
F FOR QUADRATIC FIT =     3.867
REDUCTION DUE TO QUADRATIC TERM ALONE, WITH 1 OF, =       0.014
F FOR QUADRATIC TERM ALONE =      0.634
==========================================================================

REDUCTION DUE TO GENERAL CUBIC FIT WITH OF 3, =       0.224
REDUCTION M.S. =        0.075
 RESIDUAL S.S. =        0.776  DF =       35  RESIDUAL M.S. =       0.022
  OR GENERAL CUBIC FIT =     3.362
  UCTION DUE TO CUBIC TERM ALONE WITH 1 DF = ,       0.047
  OR CUBIC TERM ALONE =   2.113
==========================================================================
```

APPENDIX J

JOB TASK CONDITIONAL AND
JOINT FREQUENCIES BY RATING

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JOB TASK CONDITIONAL AND JOINT FREQUENCIES BY RATING

This Appendix will be devoted to presenting the Job Task Conditional and Joint Frequency Matrices by rating for the data collected on the Technical Proficiency Checkout Form (TPCF). The matrices are symetric about their main diagonal and therefore only the upper triangular portion will be presented. Denote an arbitrary entry in the i^{th} row and j^{th} column $(i=1, \ldots, 8)$ as $a_{i,j}$, read left to right and top to bottom for rows and columns respectively.

For the Job Task Conditional Frequency Matrices, the entries on the main diagonal, $a_{i,i}$ $(i=1, \ldots, 8)$, are the number of technicians CHECKED OUT on the $(9-i)^{th}$ job task, but NOT CHECKED OUT on an any more difficult task. The entry off the main diagonal, $a_{i,j}$ $(i=1, \ldots, 8;\ j>i)$ is the number of technicians CHECKED OUT on the $(9-j)^{th}$ task given they are CHECKED OUT at most on the $(9-i)^{th}$ task. For example, from page J-4, there were 17 EM's who were CHECKED OUT at most on Job Task No. 7, i.e., they were NOT CHECKED OUT on Job Task No. 8. Of those 17 men 4, 13, 14, 17, 17, and 17 were CHECKED OUT on Job Task No.'s 6, 5, 4, 3, 2, and 1 res, pectively.

In the Job Task Joint Frequency Matrices, the entries on the main diagonal, $a_{i,i}$ $(i=1, \ldots, 8)$, are the number of individuals CHECKED OUT on the i^{th} task, regardless of their performance on any of the other tasks. The entries off the main diagonal, $a_{i,j}$ $(i=1, \ldots, 8;\ j>i)$, are the number of technicians CHECKED OUT on both the i^{th} and j^{th} job task. For example, from page J-4, 75 EM's were CHECKED OUT on Job Task No. 5, 42 on Job Tasks No.'s 5 and 6, etc.

ELECTRICIAN'S MATE (EM) RATING
(N = 97)

Conditional Frequencies

Job Task

8	7	6	5	4	3	2	1
55	46	33	50	50	50	52	55
	17	4	13	14	17	17	17
		6	6	5	5	4	6
			6	5	6	6	6
				3	3	3	3
					6	5	6
						0	0
							2

The number of technicians not CHECKED OUT on any job task is 2

Joint Frequencies

Job Task

1	2	3	4	5	6	7	8
95	87	87	77	75	43	63	55
	87	84	73	70	40	63	52
		87	71	69	40	62	50
			77	69	40	56	50
				75	42	56	50
					43	35	33
						63	46
							55

ELECTRONICS TECHNICIAN (ET) RATING
(N = 173)

Conditional Frequencies

Job Task

8	7	6	5	4	3	2	1
132	114	81	113	131	127	123	131
	15	5	6	15	15	11	15
		10	5	8	10	7	9
			2	2	2	1	2
				9	8	4	8
					2	1	1
						0	0
							2

The number of technicians not CHECKED OUT on any job task is 1

Joint Frequencies

Job Task

1	2	3	4	5	6	7	8
168	146	160	163	126	95	129	131
	147	146	143	117	89	118	123
		164	159	124	95	124	127
			165	125	94	129	131
				126	88	108	113
					96	83	81
						129	114
							132

FIRE CONTROL TECHNICIAN (FT) RATING
(N = 154)

Conditional Frequencies

Job Task

8	7	6	5	4	3	2	1
102	92	74	86	101	94	90	102
	8	5	6	8	8	8	8
		14	9	12	14	12	14
			15	14	12	10	14
				8	4	4	7
					2	1	2
						0	0
							1

The number of technicians not CHECKED OUT on any job task is 4

Joint Frequencies

Job Task

1	2	3	4	5	6	7	8
148	125	134	141	115	93	100	102
	125	124	121	101	86	94	90
		134	128	108	91	96	94
			143	114	90	99	101
				116	76	86	86
					93	76	74
						100	92
							102

INTERIOR COMMUNICATIONS ELECTRICIAN (IC) RATING
(N = 58)

Conditional Frequencies

Job Task

8	7	6	5	4	3	2	1
27	27	20	23	27	26	26	27
	6	1	6	5	6	6	6
		5	4	2	4	4	5
			8	7	6	4	8
				3	3	2	3
					4	3	4
						0	0
							4

The number of technicians not CHECKED OUT on any job task is 1

Joint Frequencies

Job Task

1	2	3	4	5	6	7	8
57	45	49	44	41	26	33	27
	45	45	38	36	25	32	26
		49	41	38	25	32	26
			44	37	23	32	27
				41	25	29	23
					26	21	20
						33	27
							27

RADARMAN (RD) RATING
(N = 139)

Conditional Frequencies

Job Task

8	7	6	5	4	3	2	1
26	7	6	25	14	4	5	26
	1	1	1	1	1	1	1
		1	1	1	0	0	1
			70	31	30	16	70
				3	2	2	3
					1	1	1
						2	2
							32

The number of technicians not CHECKED OUT on any job task is 3

Joint Frequencies

Job Task

1	2	3	4	5	6	7	8
136	27	38	50	97	8	8	26
	27	23	18	21	3	1	5
		38	23	34	2	2	4
			50	47	7	6	14
				97	8	8	25
					8	3	6
						8	7
							26

RADIOMAN (RM) RATING
(N = 137)

Conditional Frequencies

Job Task

8	7	6	5	4	3	2	1
13	10	[illegible]	13	13	13	12	13
	17	8	17	17	11	11	17
		29	28	22	28	24	29
			55	32	40	34	55
				4	3	3	4
					5	4	5
						0	0
							12

The number of technicians not CHECKED OUT on any job task is 2

Joint Frequencies

Job Task

1	2	3	4	5	6	7	8
135	69	100	88	113	46	27	13
	88	80	69	81	36	20	12
		100	76	91	40	21	13
			88	83	39	27	13
				113	45	27	13
					46	17	9
						27	10
							13

SONAR TECHNICIAN (ST) RATING
(N = 152)

Conditional Frequencies

Job Task

8	7	6	5	4	3	2	1
80	64	74	69	78	77	77	80
	13	11	9	12	13	13	13
		18	16	10	15	14	18
			27	15	10	10	24
				2	1	1	2
					3	3	3
						0	0
							4

The number of technicians not CHECKED OUT on any job task is 5

Joint Frequencies

Job Task

1	2	3	4	5	6	7	8
144	118	119	115	118	103	77	80
	118	118	102	99	98	76	77
		119	102	100	99	76	77
			117	101	94	76	78
				121	92	69	69
					103	75	74
						77	64
							80

TORPEDOMAN'S MATE (TM) RATING
(N = 39)

Conditional Frequencies

Job Task

8	7	6	5	4	3	2	1
8	6	6	8	8	8	8	8
	12	5	12	11	12	12	12
		3	3	3	3	3	3
			11	4	6	6	10
				5	3	2	5
					0	0	0
						0	0
							0

The number of technicians not CHECKED OUT on any job task is 0

Joint Frequencies

Job Task

1	2	3	4	5	6	7	8
38	30	31	31	33	14	18	8
	31	31	27	29	14	18	8
		32	28	29	14	18	8
			31	26	14	17	8
				34	14	18	8
					14	10	6
						18	6
							8

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APPENDIX K

THE UTILITY OF THE WRE

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THE UTILITY OF THE WRE

The purpose of this section is to demonstrate the utility of the WRE as an estimator of individual performance. Essentially it is a useful type of estimator in that it is not dependent on a convention to be adopted for the case wherein a man did not work at particular job activity. As such the convention need only provide reliability ratios for those job activities for which the man being evaluated received $\Sigma UE = 0$ and $\Sigma UI = 0$ from his supervisor.

Each square in Table 1 represents a breakdown of Table E-1 into the number (and proportion) of men who did not work at a particular job activity and those men who received $\Sigma UE = 0$ and $\Sigma UI = 0$. For example, on job activity Number 1, 19 (19.6% of the EM's) received $\Sigma UE = 0$ and $\Sigma UI = 0$ and 6 (6.2% of the EM's) did not work at that job activity. The composite reliability values need then only be employed on 19.6% of the men in that rating and job activity rather then on 25% of the men as required by the SRE, PRE, and GRE. More significantly, in the case of RD's and RM's, for example, at most 59% (as compared to 99% for the SRE, PRE, and GRE) of the men in those ratings derive reliability ratios for some job activities from the composite reliability table. Clearly this is a significant improvement which should improve individual performance estimates. The statistical analyses reported in the main text of this paper verified this conjecture.

Derivation of the Weights Employed by the WRE

On the JPQ ANSWER SHEET is Appendix A, page A-4, in column (c) for each job activity the following question was answered by the supervisor on the man he was evaluating:

QUESTION (c) Considering this man's overall performance, it is your opinion that the importance of this job activity, as a factor in determining the overall performance of this man, is best described as being:

3. of central and primary importance
2. a significant factor, but of secondary importance
1. of only moderate importance in estimating overall performance
0. of little or no importance

The weights (w_i) for the i^{th} job activity are determined by the formula:

If the supervisor recorded the i^{th} job activity as:

of central and primary importance, the weight w_i = 1.0

of secondary importance, the weight w_i = .75

of moderate importance, the weight w_i = .5

of little or no importance, the weight w_i = .25.

TABLE K-1

NUMBER AND PROPORTION OF TECHNICIANS IN EACH PROBLEM AREA

	Rating															
Job Act.	EM		ET		FT		IC		RD		RM		ST		TM	
	NZ	NW	NZ	NW	NZ	NW	NZ	NW	NZ	NW	NZ	NW	NZ	NW	NZ	NW
1	19	6	38	0	51	5	9	0	46	4	34	19	39	6	6	0
	0.196	0.062	0.220	0.000	0.331	0.032	0.155	0.000	0.331	0.029	0.248	0.139	0.257	0.039	0.154	0.000
2	16	7	47	0	48	1	7	0	52	1	27	15	36	9	13	0
	0.165	0.072	0.272	0.000	0.312	0.006	0.121	0.000	0.374	0.007	0.197	0.109	0.237	0.059	0.333	0.000
3	28	14	42	3	70	5	17	1	71	62	47	57	53	16	20	6
	0.289	0.144	0.243	0.017	0.455	0.032	0.293	0.017	0.511	0.446	0.343	0.416	0.349	0.105	0.513	0.154
4	29	14	53	30	67	26	22	5	50	25	39	38	57	19	8	2
	0.299	0.144	0.306	0.173	0.435	0.169	0.379	0.086	0.360	0.180	0.285	0.277	0.375	0.125	0.205	0.051
5	18	5	82	1	79	1	7	0	71	5	39	11	58	4	10	1
	0.186	0.052	0.474	0.006	0.513	0.006	0.121	0.000	0.511	0.036	0.285	0.080	0.382	0.026	0.256	0.026
6	38	12	83	33	79	36	24	11	59	41	42	46	58	32	15	5
	0.392	0.124	0.480	0.191	0.513	0.234	0.414	0.190	0.424	0.295	[illegible]	0.336	0.382	0.211	0.385	0.128
7	13	5	47	1	69	14	5	0	50	87	54	74	49	27	23	2
	0.134	0.052	0.272	0.006	0.448	0.091	0.086	0.000	0.367	0.626	0.394	0.540	0.322	[illegible]	0.590	0.051
8	22	13	48	0	60	4	12	0	51	81	50	64	45	16	18	4
	0.227	0.134	0.277	0.000	0.390	0.026	0.207	0.000	0.367	0.583	0.365	0.467	0.296	0.105	0.462	0.103

Number of Men Each Rating

EM	ET	FT	IC	RD	RM	ST	TM
97	173	154	58	139	137	152	39

NZ = Number and Proportion of Technicians Who Received $\Sigma UE=0$ and $\Sigma UI=0$

NW = Number and Proportion of Technicians Who Did Not Work at that Job Activity

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13. ABSTRACT

The purpose of this research effort is to validate the utility and effectiveness of a unique human performance measurement technique developed under ONR contract (N0001467C0107). Performance data on eight Navy ratings was collected from ships of LANTFLT and PACFLT. This report is the last in a series of technical reports on the statistical analysis of that data. A statistical analysis is provided on performance related data for electronic maintenance personnel sampled from 21 ships. Four different performance estimators, as functions of critical incidents, were evaluated. A detailed explanation of the distributional properties of the performance estimators is presented and an explanation of the factors that lead to the adoption of a curvilinear regression analysis for analysis of the data is discussed.

The results of the statistical analysis indicated that a certain combination of the performance data possessed moderate validity for appraising the absolute level of technician on-the-job performance in the EM, ET, FT, and IC ratings. Application of the technique to technicians in the RM, ST, and TM ratings was tenuous, but still appropriate, while none of the performance estimators seemed to be applicable to technicians in the RD rating. For this reason it would seem that the appropriateness of application of this technique to other ratings warrants investigation, perhaps by the approach employed in this report. In any event it has been observed that the technique possesses sufficient merit to be recommended for more widespread use within the U. S. Navy.

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